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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
DIGITAL INSTRUMENTATION AND CONTROL SYSTEMS
SUBCOMMITTEE

+ + + + +

MEETING

+ + + + +

FRIDAY, FEBRUARY 27, 2009

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ROCKVILLE, MD

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The Subcommittee was convened in Room T2B3 in the Headquarters of the Nuclear Regulatory Commission, Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Dr. George Apostolakis, Chair, presiding.

Subcommittee MEMBERS PRESENT:

GEORGE APOSTOLAKIS, Chair

CHARLES H. BROWN, JR.

MARIO V. BONACA

JOHN W. STETKAR

DENNIS C. BLEY

JOHN D. SIEBER

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CONSULTANTS TO THE Subcommittee PRESENT:

SERGIO GUARRO

MYRON HECHT

NRC STAFF PRESENT:

CHRISTINA ANTONESCU, Designated Federal
Official

MICHAEL WATERMAN

STEVEN ARNDT

ALSO PRESENT:

RICHARD WOOD

RAY TOROK

TED QUINN

MIKE CASE

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Nuclear Power Plant Instrumentation and Control
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3 P-R-O-C-E-E-D-I-N-G-S

4 8:28 a.m.

5 CHAIRMAN APOSTOLAKIS: This is the second
6 day of the ACRS Subcommittee meeting on the digital
7 I&C. Mr. Waterman has the floor.

8 Please.

9 MR. WATERMAN: Thanks, George.

10 Just to bring us back to where we were
11 yesterday, yesterday we talked about the issues that
12 are to be addressed by the research, the diversity
13 attributes and criteria that we are using. We then
14 went into some operating experience considerations
15 just briefly. We talked about the sources of data
16 we're using and talked about some of the research
17 assumptions that we used when we did the research.

18 And so today we'll pick it up from the
19 data evaluation method by first recapping some of the
20 research assumptions. And this will be on slide 23,
21 for those of you who want to come up to speed on that.

22 The research assumptions were, we said
23 we'd use diversity positions and designs used by other
24 people on the basis that they probably used operating
25 experience and judgment in developing those designs,

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1 that we would then try to correlate that information
2 with NUREG/CR-6303, diversity attributes and criteria.

3 And that by doing that, we should be able to develop
4 an evaluation process that we could apply the design
5 to. Well, the new design's in. You'll see how they
6 stack up, if you will, against what the rest of the
7 world is doing. And then we would try to capture some
8 better perspectives out of industry and nuclear power
9 plant operating experience and see if that could help
10 us in developing this method.

11 So practically speaking, what we did was
12 we took the NUREG/CR-6303, diversity criteria and
13 attributes. And there's a circle here; the rest of
14 them aren't, but that's all right. We transferred
15 that data into a spreadsheet format. We used
16 Microsoft Excel spreadsheet. And by taking those
17 diversity criteria; they were ranked in 6303 as I
18 explained yesterday, we developed a simple waiting
19 system that would give more emphasis to more effective
20 criteria and less emphasis on less effective criteria.

21 CHAIRMAN APOSTOLAKIS: So, you know, let
22 me understand this a bit better.

23 MR. WATERMAN: I'll get into the actual
24 weighting assumptions and stuff like and --

25 CHAIRMAN APOSTOLAKIS: But what's the

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1 intent? Why are we doing all this?

2 MR. WATERMAN: We're doing this to develop
3 a method of evaluating proposed diversity approaches.

4 Say a licensee determines off of a BTP 7-19 analysis
5 that they need a diverse low-pressure injection
6 actuation system because the operator doesn't have
7 enough time to respond to a large-break LOCA. And so
8 they need to develop a diverse system to do the
9 automatic initiation of low-pressure injection.

10 The question that's always come up is they
11 propose a design and then they don't know whether that
12 design is diverse enough to meet all the criteria it
13 needs to meet, have sufficient diversity. Because
14 there's been a lot of uncertainty, regulatory
15 uncertainty as licensees propose designs and the
16 regulator says well, I don't know if that's enough.
17 Is it really diverse, and things like that. And we're
18 trying to nail that down to where there's not all of
19 that uncertainty, that when a licensee proposes a
20 design using this method here, verifying it through
21 this method here, that the NRC staff can also use this
22 method to verify, yes, it looks like it's diverse
23 enough and we, through our review process, confirm
24 yes, all of those features are in the design.

25 And so, the easiest way to do that is if

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1 you have some numerical range to start out with, then
2 you can screen out diverse designs that just don't fit
3 into the range. They're way too low, for example.
4 And designs that are within that range, the licensee
5 has some, if you will, certainty that it's probably
6 good enough.

7 CHAIRMAN APOSTOLAKIS: So essentially you
8 are developing a metric called diverse --

9 MR. WATERMAN: Thanks. That's a very good
10 way to put it.

11 CHAIRMAN APOSTOLAKIS: And if this is -- I
12 mean, the scale is what, zero to one?

13 MR. WATERMAN: Well, the scale is zero to
14 some number just slightly less than two.

15 CHAIRMAN APOSTOLAKIS: Okay.

16 MR. WATERMAN: When you plug all the Xs
17 in, it comes up --

18 CHAIRMAN APOSTOLAKIS: Yes.

19 MR. WATERMAN: But 1.0 would represent the
20 average diversity that we've seen in the applications
21 that we've actually tried to address deliberately
22 diversity strategy.

23 CHAIRMAN APOSTOLAKIS: So if I have to
24 designs and one has a metric of 1.2 and the other .7,
25 then I can claim the one with 1.2 is more diverse?

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1 MR. WATERMAN: Yes, exactly. It is
2 probably more likely to be accepted and approved in a
3 review process.

4 MEMBER BROWN: There was another comment
5 you made yesterday day though about effective. The
6 higher the number, the more effective.

7 MR. WATERMAN: Yes, the --

8 MEMBER BROWN: Relative to whatever the
9 diverse --

10 CHAIRMAN APOSTOLAKIS: Yes. Yes.

11 MR. WATERMAN: No, the thing I have to
12 keep focusing myself on, and I hope everybody else
13 does, the mission here isn't how much diversity is in
14 the system, right? The mission is to address common-
15 cause failures, not just to build diverse systems.
16 The idea of a diverse system os to address some
17 potential range of common-cause failures. That's
18 where operating experience can help out and where
19 engineering judgment can help out, is to identify the
20 common-cause failures that have to be addressed. And
21 so any diversity strategy should be focusing on we've
22 got a common-cause failure microprocessor. Okay.
23 We'd better do something about some diversity in that
24 area so that if that occurs we're not affected in our
25 diverse system.

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1 MEMBER BROWN: So another way to phrase
2 that, you're really trying to develop a ranking that
3 would give you a numerical metric or a numerical
4 ranking of how effective is the diverse system you've
5 designed at combatting, or taking care of, or
6 addressing common-cause failures?

7 MR. WATERMAN: That's correct.

8 MEMBER BROWN: So you have to add the add
9 addressing and its effectiveness on doing CCFs, right?

10 MR. WOOD: I would add the caution, too,
11 that this is more of a comparative tool than and
12 absolute measure of diversity, because there's not a
13 set of metrics that provide a comprehensive well-
14 defended number. But this does provide a very
15 systematic and effective tool for doing comparative
16 assessment of the diversity strategies that might be
17 proposed.

18 MEMBER BLEY: Now, the effectiveness of a
19 particular strategy against a particular kind of
20 common cause might be different than against another
21 kind of common cause.

22 MR. WATERMAN: Oh, absolutely. Yes,
23 you're right.

24 MEMBER BLEY: But that there's no way to
25 -- you're not trying to track anything.

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1 MEMBER BROWN: I don't think --

2 MEMBER BLEY: So it's just kind of the
3 best thing that -- when you look at it and try to
4 evaluate it, is this the best it performs against any
5 common cause? It probably can't be on average,
6 because who knows what that is?

7 MR. WATERMAN: Not any common cause. The
8 real trick in doing BTP 7-19 analyses or NUREG/CR-6303
9 analyses is to identify which common causes do I have
10 to address. Now one system may have a set of common
11 causes that they've identified and another system may
12 not be subject to that same set of common causes. And
13 so those two diverse designs will be different because
14 the idea of a diverse system is to address the common
15 causes that have been deemed to be --

16 MEMBER BLEY: So this you have to apply to
17 one specific area of the design?

18 MR. WATERMAN: You can have a design that
19 addresses several different common causes all in one
20 design.

21 MR. WOOD: And they might not all be
22 implemented on the same system. You can implement
23 some of these diversity strategies within your safety
24 system, like the functional diversity is an example
25 that's very common, and then implement some of the

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1 other diversities in a diverse actuation system as
2 well. In the underlying rationale, and there's a
3 great deal of it in chapter 6 of the NUREG report, it
4 talks about the effectiveness or the effect, impact of
5 these different diversities on those areas that I
6 mentioned yesterday, the purpose, the process the
7 product and the performance and whether or not you're
8 dealing with the introduction of systematic faults or
9 you're dealing with common responses to external
10 stimuli or common demand space, things like that. So
11 in applying this tool, it can't just be used as I'm
12 looking at a number and that's all I need to know.
13 You need to verify some assumptions and the way you
14 characterize the diversities and also have tie to the
15 application space that you're talking about. The
16 caution really is this is still a subjective analysis.
17 It's just a systematic rigorous way of looking at
18 that subjective analysis. But we need a caution about
19 losing sight, that it is still a subjective analysis.

20 MEMBER BLEY: I guess where I'm coming
21 from is I see parallels between this and what we tried
22 to do in safety analysis many years ago; more people
23 are trying to do in proliferation resistance analysis
24 and that's trying to see some intrinsic value to some,
25 I'll call it a barrier or a system. The trouble was

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1 it really is dependent on the scenario you're focused
2 on. In that case, that scenario is in common cause.
3 So without that framework, there really is no
4 particular intrinsic value to any --

5 MR. WATERMAN: Yes.

6 MEMBER BLEY: So I think we're on the way,
7 but maybe this refines over time or application.

8 MR. WATERMAN: Mind you, licensees aren't
9 require to put in -- if a licensee identifies that
10 they need some diverse system, because, for example,
11 the operator doesn't have enough time to respond to an
12 event, say it's low-pressure injection actuation, that
13 doesn't mean they have to put in containment isolation
14 into that diverse system and containment spray and
15 high-pressure injection, all that. They only need to
16 put in diverse systems to handle the functions that an
17 operator may not have enough time to address.

18 MEMBER BLEY: And then you evaluate
19 against that particular --

20 MR. WATERMAN: That's correct. The
21 example that comes to mind is the Oconee upgrade,
22 they're putting in a diverse low-pressure injection
23 actuation system and I believe a diverse high-pressure
24 injection actuation system. They're not doing diverse
25 containment isolation or any of the other engineer

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1 safety feature actuations. They're not putting in a
2 diverse reactor trip.

3 CHAIRMAN APOSTOLAKIS: Who is doing the
4 evaluation of the weights, the licensee or the staff?

5 MR. WATERMAN: The staff. Research right
6 now has developed these set of weights.

7 CHAIRMAN APOSTOLAKIS: And then who's
8 going to use them? I mean, the licensee or the staff?

9 MR. WATERMAN: It would be my hope that
10 the licensee would use this tool and the staff would
11 also use the very same tool with the exact same
12 weights that everybody's working on the same sheet of
13 music, if you will. So that when the licensee does an
14 evaluation, identifies the common-cause failures they
15 need to address and uses this tool maybe even to help
16 them design the system, that once they design it and
17 they come up with score of, say, .94, which should be
18 well within the region of acceptability, when they
19 submit it to the Agency and the Agency runs those same
20 assumptions, the Agency should also come up with a
21 score of .94. And, you know, if they don't, then
22 there's something going on there that is causing
23 licensing uncertainty, and licensing uncertainty is a
24 safety concern.

25 CHAIRMAN APOSTOLAKIS: The licensee will

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1 come here and say for low-pressure system actuation we
2 calculated the weight and it's 1.1. They're not going
3 to give you an alternate design. They will just say
4 this is the design, we propose 1.1. What is that
5 telling you? Are you going to have some standard that
6 says for these kinds of things 1.1 is good enough?

7 MR. WATERMAN: I'm actually going to talk
8 about that a little bit later in the presentation.

9 CHAIRMAN APOSTOLAKIS: Okay.

10 MR. WATERMAN: We haven't yet determined
11 the region of acceptability, but I can guarantee it's
12 not as tight as 1.01 down to .99. It's going to be a
13 much broader region. And in order to use this as a
14 screening tool to tell us this is within reason; let's
15 take a look at what they did, or this just doesn't
16 look reasonable at all. Let's take a look at what
17 they did and we'll discuss it.

18 CHAIRMAN APOSTOLAKIS: Now, the other
19 thing is you said earlier for these kinds of common-
20 cause failures or, I guess, in all the presentations
21 yesterday we avoided going into the causes. We were
22 looking at the symptoms. But that's what you meant,
23 too? We're losing, you know, two redundant parts of
24 the system, for whatever reason.

25 MR. WATERMAN: For whatever reason.

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1 CHAIRMAN APOSTOLAKIS: And then we are
2 designing against that, how to protect it and mitigate
3 it. That's what you meant. The symptoms?

4 MR. WATERMAN: Yes.

5 CHAIRMAN APOSTOLAKIS: Yes.

6 MR. WATERMAN: Exactly.

7 MR. WOOD: NUREG 6303 D3 analysis sort of
8 can be characterized as a top-down approach of looking
9 at the use and you can take a bottom-up approach.
10 It's just very difficult to claim that you've
11 identified all of the potential vulnerabilities.

12 CHAIRMAN APOSTOLAKIS: Okay. Now, we can
13 move onto the details.

14 MR. WATERMAN: So, we gathered data from
15 around the world, from organizations such as the IEC
16 and the Federal Railway Administration and Federal
17 Aviation Administration. We also looked at different
18 industries like the rail industry, the chemical
19 industry, aerospace and aviation. And then we also
20 looked at what's going on in international nuclear
21 power plants.

22 MR. WOOD: I want to add that we looked at
23 other industries as well. It's just in many cases
24 those industries don't specifically as a response to
25 common-cause failure, and in some cases they don't

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1 identify common-cause failures.

2 CHAIRMAN APOSTOLAKIS: Do they even use
3 the words?

4 MR. WOOD: In some, they don't. And they
5 do rely on the first line of defense, which is high-
6 quality process and very much rigor in their
7 engineering approach.

8 MR. WATERMAN: So we took the data that we
9 gathered and we populated our spreadsheet with the
10 various, if you will, diversity strategies that we
11 saw. And by doing that, we were then able to
12 determine how many of these criteria were used in the
13 data set; we summed them up here, and how many times a
14 particular attribute was used out of all of the people
15 that we looked at.

16 Doing that, we were able to determine a
17 diversity attribute effectiveness weight, which is a
18 weight sort of representative of -- for example, of
19 the 14 designs that actually had deliberate
20 application of diversity, it looks like all 14 of them
21 use some design diversity approach. And so, 14
22 divided by 14, that would give us a value of 1.0 for
23 the diversity attribute effectiveness weight for the
24 design attribute. And we went through there. We'll
25 get into all the assumptions underlying. That's very

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1 simple, simplistic. I realize that, but it's a step I
2 think in the right direction to developing a metric.

3 CHAIRMAN APOSTOLAKIS: Can you walk us
4 through an example here?

5 MR. WATERMAN: Right now?

6 CHAIRMAN APOSTOLAKIS: Pick one, yes.

7 MR. WATERMAN: I don't think I have any in
8 my slides.

9 CHAIRMAN APOSTOLAKIS: Well, the first row
10 here that says --

11 MR. WATERMAN: Well, but it only goes down
12 to, you know, the function part. The first row here
13 is we have -- this application, it's just labeled
14 design 1. I could bring up the spreadsheet, if you'd
15 like, but it's --

16 CHAIRMAN APOSTOLAKIS: No, let me tell you
17 what I'm trying to understand. There is an arrow from
18 the attribute design. Says different approach, same
19 technologies, I guess. And you go to different
20 technologies and you give it a rank of one. That's
21 the first row, right?

22 MR. WATERMAN: You're talking about right
23 here?

24 CHAIRMAN APOSTOLAKIS: The very first row.

25 MR. WATERMAN: The different technologies?

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1 CHAIRMAN APOSTOLAKIS: Different
2 technologies. The first row.

3 MR. WATERMAN: Yes. Oh, different
4 technologies, and we've got line No. 2 using different
5 technologies. And by using different technologies, in
6 other words, we're probably backing up a digital with
7 an analog system.

8 CHAIRMAN APOSTOLAKIS: Right.

9 MR. WATERMAN: Or maybe backing up an
10 analog system with a digital system.

11 CHAIRMAN APOSTOLAKIS: But why is the rank
12 one?

13 PARTICIPANT: That's just a number.

14 MR. WATERMAN: Because NUREG/CR-6303
15 ranked these diversity criteria according to their
16 relative effectiveness compared to the other criteria
17 within that attribute. So, using different
18 technologies as a design diversity is considered to be
19 more effective than using the same technology and just
20 changing the architecture, which is down here at
21 three.

22 CHAIRMAN APOSTOLAKIS: Okay.

23 MR. WATERMAN: So this is the best
24 approach, second best approach for relative
25 effectiveness, third best approach.

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1 CHAIRMAN APOSTOLAKIS: Okay. So this is
2 the judgment of the authors of 6303?

3 MR. WATERMAN: That's correct.

4 CHAIRMAN APOSTOLAKIS: Fine.

5 MR. WATERMAN: And for the most part when
6 you read it, this sort of makes sense.

7 CHAIRMAN APOSTOLAKIS: The second column
8 says DCE Wt.

9 MR. WATERMAN: And I'll get into the
10 development of the diversity criterion effectiveness
11 weight, and I'll talk about why I came up with those
12 numbers, or how I came up with those numbers. Okay?

13 CHAIRMAN APOSTOLAKIS: Okay.

14 MR. WATERMAN: This is just sort of a
15 recap of what we're going to be discussing in the
16 follow-up slides.

17 CHAIRMAN APOSTOLAKIS: So we'll come back
18 to a table like this?

19 MR. WATERMAN: Yes, I'll probably
20 demonstrate how the tool actually works, but yes.

21 So after populating it and getting a
22 diversity attribute effectiveness weight, now I've got
23 my weights. I've got my diversity criterion
24 effectiveness weight that I just developed off of the
25 various relative effectivenesses of the criteria

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1 within an attribute; that's these weights right here,
2 and I've got a diversity attribute effectiveness
3 weight that's really representative of the frequency
4 of usage of that attribute around the world, if you
5 will, from the things that we looked at.

6 We transferred those weights and the
7 criteria and the attributes into a new table such that
8 we could populate that table in new designs that were
9 proposed and from those designs we could then come up,
10 if you will, with a score using the weights that we
11 developed. And this is sort of the tool that will be
12 looking at later on, if you want a demonstration of
13 it. Charlie and I played around with it a little bit
14 yesterday.

15 CHAIRMAN APOSTOLAKIS: So at some point
16 you will give us a demonstration --

17 MR. WATERMAN: Sure.

18 CHAIRMAN APOSTOLAKIS: -- of how these
19 numbers --

20 MR. WATERMAN: Absolutely. I'd love to.

21 CHAIRMAN APOSTOLAKIS: Okay. Jack?

22 MEMBER SIEBER: This really doesn't tell
23 you where diversity is needed. This tells you where
24 diversity is used by practitioners to overcome
25 problems that they perceive could occur. Right?

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1 MR. WATERMAN: Thank you, Jack. That's
2 exactly right. This does not defend whether or not
3 diversity is needed. It only says once that
4 determination is made, you have to address it and how
5 do --

6 MEMBER SIEBER: Yes, here's how people do
7 it.

8 MR. WATERMAN: Yes.

9 MEMBER SIEBER: Okay.

10 MR. WATERMAN: Thanks, Jack.

11 MEMBER SIEBER: This is a history lesson.

12 MR. WATERMAN: This is sort of a history
13 lesson, yes.

14 MEMBER SIEBER: Yes. Okay.

15 MR. WOOD: The tool provides an excellent
16 mechanism for capturing those kind of experiences.

17 MEMBER SIEBER: Well, it also gives you
18 the framework in which one thinks about how to achieve
19 their goals. You know, without the framework, I'm not
20 exactly sure what one would do.

21 MR. WATERMAN: We don't seem to have a
22 good framework.

23 MR. WOOD: It's a multi-dimensional
24 problem.

25 MEMBER SIEBER: Well, this is a good first

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1 step.

2 MR. WATERMAN: This is a first step.

3 MEMBER SIEBER: Yes.

4 MR. WATERMAN: So, in summary, we
5 developed a spreadsheet using the 6303 guidance as a
6 framework to capture diversity designs and positions
7 from other organizations, industries and companies,
8 countries. And the data and the guidance was in use
9 to develop weights and the weights were used to store
10 the designs and positions. And this is sort of a
11 breakdown of how the attribute usage came out for the
12 designs we looked at. You can see that there's about
13 20 percent of the applications. From this slide you
14 it can be seen that the distribution of diversity
15 attributes is approximately 20 percent usage for life
16 cycle; here, the orange, logic in the red. And signal
17 diversities, it varies between seven percent and 13
18 percent for the remaining diversity attributes. And
19 this is not surprising in that life cycle diversity
20 and logic diversity have been used extensively in
21 response to licensing uncertainty rising from
22 incomplete guidance on the use of diversity.

23 People just said, well, we'll just build
24 it as good as we can and we'll try different
25 algorithms and things like that. And since the

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1 signals are already in the plant, you know, they just
2 used what they could.

3 MEMBER BROWN: So this is the fraction of
4 all those existing systems you looked at and how they
5 approached dealing with -- they had to design a
6 diverse system and this is the approach that the
7 various you look at took, just a breakdown of those.

8 MR. WATERMAN: Yes.

9 MEMBER BROWN: Okay.

10 MR. GUARRO: Have you tried to make a
11 judgment as to -- you know, because you have looked at
12 different industries, right?

13 MR. WATERMAN: Yes.

14 MR. GUARRO: You tried to make judgment as
15 to whether there is a difference in usage between
16 industries that have more awareness of the problem of
17 diversity versus industries that have less awareness
18 of them, because that's a little bit of a concern that
19 comes to mind. Because I mean from my personal
20 experience I know that there are certain industries
21 that they don't even, as George was saying, the word
22 "diversity" isn't even in their vocabulary.

23 MR. WATERMAN: And actually, when I do the
24 summary plot of how everything scored out using this
25 particular score, you'll see that arise. Sometimes

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1 industries don't look at diversity simply because they
2 don't have enough room to put another rack, for
3 example. Or the domain space in which they're
4 operating doesn't lend itself to diversity.

5 MR. GUARRO: You know, in the space system
6 industry where I work there's no room for diversity
7 for that very reason.

8 MR. WATERMAN: Exactly.

9 MR. GUARRO: And there is no material and
10 room.

11 MR. WOOD: In the examples from NASA there
12 was some usage of diversity, although it's not the
13 primary response and a lot depends on whether it's a
14 "human rated mission" or a "deep space mission."

15 MR. GUARRO: Yes. Right.

16 MEMBER SIEBER: How much of a function
17 applying diversity is the fact that some malfunctions
18 or accidents that you could have really just don't
19 mean that much from the standpoint of economic cost,
20 or danger to people, or what have you? Is that a
21 function that's hidden all of this?

22 MR. WATERMAN: There is some cost benefit
23 functions in there. You know, it would be great if
24 everybody chose different technologies. Sometimes
25 there's just not a cost benefit in going with

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1 completely different technology and so somebody might
2 back off and say well, instead of different
3 technologies where we can't get the analog parts, for
4 example, let's try FPGA's backing up microprocessors.

5 We'll ramp it down a little bit and we'll go with
6 that. And I think that cost benefit is sort of
7 implied by how many of these different criteria were
8 selected overall.

9 MEMBER SIEBER: Yes, if you're control
10 system messes up and the result is you burst some tank
11 some place it doesn't hurt anybody, doesn't cause
12 environmental damage, can be repaired, you know, why
13 would I put in an expensive diverse system to deal
14 with it?

15 MR. WOOD: The application of diversity,
16 whether or not it's applied addresses the issue of is
17 it important. There are faults and I don't care that
18 they exist because they don't cause a failure that I'm
19 concerned about. This looks at when it's been decided
20 diversity is needed, when the industry or the
21 application decided what kinds of diversity were
22 applied.

23 MEMBER SIEBER: You face the same thing in
24 a nuclear power plant. Depending on what the system
25 is and what function you're performing at a given

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1 time, you may decide I don't need to spend money on
2 diverse instrument and control systems because if it
3 breaks, it's not going to lead to core melt, it's not
4 going to lead an off site --

5 MR. WATERMAN: Yes, as a matter of fact,
6 Branch Technical Position 7-19 addresses that very
7 point.

8 MEMBER SIEBER: Yes.

9 MR. WATERMAN: When it says look at your
10 potential common-cause failures. For each one you
11 see, run it through your pseudo design basis analysis
12 and look at the consequences. Now the consequences
13 don't rise to some level of significance; for example,
14 10 C.F.R. 100, 10 percent of 10 C.F.R. 100, you're
15 done. But if you do exceed those, then put in a
16 diverse system to address it. And that last thing,
17 put in a diverse system to address it is where this
18 would come in.

19 MEMBER SIEBER: Well, what defines the
20 boundary? Part 100?

21 MR. WOOD: For the D3 analysis.

22 MR. WATERMAN: For the D3 7-19, yes.
23 Well, part of this part 100, part of it's how much
24 fuel damage you get and those limits are less than the
25 10 C.F.R. 100 limits.

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1 MR. WOOD: But they're addressed as
2 criteria in 6303.

3 MEMBER SIEBER: Okay.

4 MR. WATERMAN: So 7-19 essentially says,
5 okay, look, you need some diversity. And what this
6 research is doing is saying, okay, now that you
7 determine you need it, how much is enough? Are you
8 really diverse enough?

9 MEMBER SIEBER: So if you're getting close
10 to some limit, then your first thought as a designer
11 is I'll put in a diverse system and hopefully avoiding
12 hitting that limit. But you never really know for
13 sure because of the complexity of the situation
14 whether you do or don't, right?

15 MR. WATERMAN: Yes, that's right.

16 CHAIRMAN APOSTOLAKIS: So, what kind of
17 complexity are we talking about here? I mean, if I
18 have a simple actuation system, would I have to do all
19 this?

20 MR. WATERMAN: Well, if you have a simple
21 actuation system and you run it through your BTP 7-19
22 analysis and you do not exceed those threshold limits
23 that are described in BTP 7-19 and the SRM to SECY 93-
24 087, then you don't need diversity.

25 CHAIRMAN APOSTOLAKIS: But it's a scram

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1 system?

2 MR. WATERMAN: Yes.

3 CHAIRMAN APOSTOLAKIS: That probably
4 exceeds those limits, doesn't it?

5 MR. WATERMAN: Well, on a large-break LOCA
6 I don't know that you need to scram the reactor. I
7 could have scrambled it anyway.

8 CHAIRMAN APOSTOLAKIS: So now what you're
9 saying is that I have to look at the actuation system
10 in the context of an accident sequence?

11 MR. WATERMAN: Yes. That's right.

12 CHAIRMAN APOSTOLAKIS: And then, I mean,
13 do I have to worry about all this? I mean, are these
14 systems simpler than day -- the example that always
15 brought up, you know, the control system of the
16 Ariane rocket in Europe where people give you, you
17 know, weird things that happen and they say, well
18 look, you nukes don't worry about these things. Well,
19 that was a system that controlled the whole damn
20 rocket. Here, all I have to do is insert the rods. I
21 still have to worry about all this? I mean, is there
22 an issue of complexity here and utilization of the
23 system? Is it overkill, on other words?

24 MR. WATERMAN: Well, keep in mind, this
25 doesn't address whether or not there's a need for

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1 diversity.

2 CHAIRMAN APOSTOLAKIS: You're right.

3 MR. WATERMAN: This addresses the question
4 that once somebody determines there is a need for
5 diversity, how do you make sure you've got enough?
6 And like you say, this is like a metric that helps you
7 screen somewhat and get a comfort level, if you will,
8 of licensing certainty and safety.

9 MR. WOOD: There are some differences in
10 the decision making in Europe. Let's say in Britain
11 they tend to use a risk based argument for determining
12 which functions need to be backed up by a diverse
13 system.

14 MEMBER SIEBER: Yes, I can't think of any
15 other way to do it. Are we going to require the same
16 thing? You know, you put in a diverse system and you
17 say I've reduced my chances, but you have to do a
18 specific analysis to determine the extent to which
19 you've reduced your chances. And so are there
20 boundaries on -- you know, no one can guarantee that
21 you aren't going to have a series of screw-ups that
22 eventually are going to lead to disaster. Is there a
23 limit as to what the risk is after you've applied
24 various diverse techniques in order to determine
25 whether you've done enough or not, other than a cost

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1 benefit?

2 MR. WATERMAN: That's looking at the space
3 of the common-cause failure and determining their
4 credibility.

5 MEMBER SIEBER: Yes.

6 MR. WATERMAN: Right? And then addressing
7 the ones that are most credible. Now, this research
8 here did not address the area of what's credible and
9 what's not credible.

10 MEMBER SIEBER: Yes, but where do we from
11 here? Because this then doesn't define the total
12 answer. It doesn't tell me what to do, right, without
13 additional work.

14 MEMBER BONACA: How do you deal with other
15 attributes? What I mean is that, here you have
16 alternatives focused on diversity. They measure how
17 much diversity you get. But each one of these
18 engineering solution, they have other attributes.
19 Which is more desirable than other of these solutions?
20 How do you weigh that?

21 MEMBER SIEBER: That's another way to ask
22 the question.

23 MEMBER BONACA: What?

24 MEMBER SIEBER: It's another way to ask
25 the same question.

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1 MR. WATERMAN: You mean attributes in
2 addition to the seven attributes here, Mario?

3 MEMBER BONACA: Yes, in addition to the
4 diversity, measuring that, but each one --

5 MR. WOOD: There are two ways of
6 characterizing a response to a common-cause failure
7 vulnerability. One is to prevent the potential posed
8 by that vulnerability. The other is to mitigate the
9 fact that that's there. Diversity tends to lead
10 toward mitigation. Design tends to lead toward
11 prevention. And like I mentioned, some industries
12 that aren't reported, that don't discuss diversity
13 tend to focus on the design, the rigor of the design,
14 the ability to identify hazards and address those
15 hazards in the design and following that through with
16 a very rigorous review process and confirmation
17 process. But even in those industries they can't
18 claim that they've avoided the common-cause failure.
19 They can only say that they've done what was
20 reasonable or practical to address it through design.

21 CHAIRMAN APOSTOLAKIS: Several times,
22 Mike, you had to, or you felt that you had to say, you
23 know, that you started with BTP such-and-such. I
24 think and the questions you got from Jack from Mario
25 seems to me would help your cause here to have some

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1 sort of a block diagram that sends a message of what
2 really is happening in real life, that the analyst
3 will start by doing an evaluation according to this
4 BTP. If the analyst finds this, then he or she
5 determines that there is a need for this. If he finds
6 something else, then this will be placed in its right
7 context. It seems to me that's an important thing.
8 Because every time that you get a question, both you
9 and Richard have to go back and say but, we don't
10 determine the need, we don't do this, we don't that.
11 So if you have one picture that will show that and say
12 now, here, down here is where we are working today,
13 then I think that will communicate better what you're
14 trying to do.

15 MR. WATERMAN: That's a great idea. I
16 like pictures, so thanks, George.

17 CHAIRMAN APOSTOLAKIS: Okay.

18 MR. WATERMAN: I put a little note right
19 here. You never know what will happen --

20 CHAIRMAN APOSTOLAKIS: Why is little note?
21 I said a lot of things.

22 MR. WATERMAN: I write small.

23 MEMBER SIEBER: To do what George is
24 suggesting is not trivial.

25 CHAIRMAN APOSTOLAKIS: What? What did you

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1 say Jack? I'm sorry.

2 MEMBER SIEBER: To do what you're
3 suggesting is not trivial.

4 CHAIRMAN APOSTOLAKIS: Is not trivial, but
5 it seems to me that's why we have this discussion,
6 because people try to think at that higher level and
7 evaluate what these gentlemen are --

8 MEMBER SIEBER: I think it can be done,
9 but it's a lot of work.

10 CHAIRMAN APOSTOLAKIS: Yes. Yes.

11 MEMBER SIEBER: The way I picture it.

12 CHAIRMAN APOSTOLAKIS: Okay.

13 MR. GUARRO: Just to complete a little bit
14 the question that I was asking before, were you able
15 to look at a pie chart like that by different
16 industries and industries and see if there was a
17 substantial difference in the relative use of the
18 different attributes.

19 MR. WATERMAN: You know, I didn't think of
20 that, but it's not hard to do.

21 MEMBER BROWN: You mean within an industry
22 or between industries?

23 MR. GUARRO: No, between industries.

24 CHAIRMAN APOSTOLAKIS: Why are you
25 interested in this, Sergio? I mean, I know you are

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1 interested, but --

2 MR. GUARRO: Well, because I don't think
3 all industries are equally aware of the relevance of
4 this issue in the same way. And so, you know, in
5 other words, to adopt a criterion of goodness based on
6 an industry that doesn't do diversity very well seems
7 to -- and diluting the -- an industry that does it
8 well doesn't seem to be the right thing to do.

9 MR. WOOD: If I could make an observation.
10 We did that, not through pie charts, but for example,
11 the aerospace industry, the NASA examples, which show
12 very low on these scores, they have a context issue
13 because of size, power and weight limitations. That's
14 a constraint that we had to consider in determining
15 whether or not it needed to be factored into
16 determining this region. The aviation industry, on
17 the other hand, they also have some size and weight
18 limitations, but they also are dealing with a problem
19 space that's different. They're an active control
20 system with a very immediate indication of a failure.

21 MR. GUARRO: I understand, but for that
22 very reason, because the contexts are different and,
23 you know, so maybe you don't see, you know, that the
24 distributions change much and that would be a
25 confirmation that everybody does more or less the same

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1 thing. But otherwise, if you see a difference, then
2 you should ask yourself why the difference and make a
3 judgment as to who has the better solution, rather
4 than mix them together blindly.

5 MR. WATERMAN: Skipping ahead on the
6 presentation, this shows the breakdown. Boy, this is
7 way ahead, this slide 47. The public handouts, it's
8 all bad, but you guys have the really good handouts.
9 The applications of positions that we use to develop
10 the weights and the normalized score are shown between
11 these two red lines here. We screened out
12 applications that had either size, weight or
13 functional domain restrictions to them. They weren't
14 useful, like you said. They just weren't
15 representative of what the nuclear industry faces.
16 For example, the nuclear industry uses a design
17 system. They got plenty of space for another rack.
18 They can put in a different system. You go off on
19 international space station or space shuttle, you
20 don't have that luxury.

21 So we pretty much screened all the
22 aerospace and aviation application. Additionally, we
23 screened out one of the applications out of non-
24 nuclear industrial applications. We screened out one
25 of the international positions and we screened out one

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1 of the plant designs that we gathered, because they
2 were using minimal diversity. And so what we're
3 looking for is how much is enough, so we just screened
4 it out of this calculation here. And then what was
5 left were fairly energetic, if you will, diversity
6 approaches that we then used to score the normalized
7 value of 1.0 and develop all the weights just on these
8 here. So we didn't use pie charts or anything, but we
9 did sort of look at what they were doing and decide
10 well, is this really something that the nuclear
11 industry can benefit from? And it was like no, not
12 really, because you know, we're talking apples and
13 oranges.

14 MR. WOOD: But I want to note that just
15 because they were screened out of the use and the tool
16 didn't mean that we through away the insights that can
17 be gained. For example, in the aviation industry,
18 even with the size and weight limitations, there's a
19 use of different microprocessors to provide some
20 diversity. And we consider that very significant
21 because it sort of flew in the face of size and weight
22 limitations. And we looked at the rationale that was
23 provided on why they did that and also considered
24 those things. In the report there are some baseline
25 strategies or groupings of strategies that factor

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1 those kind of considerations in and they assess very
2 well using the tool.

3 MEMBER SIEBER: Another factor that I
4 think is there that we haven't fully evaluated is the
5 tolerance of the public for mishaps in various
6 industries. For example, the public is sort of
7 satisfied with killing 40,000 or 50,000 people a year
8 in automobiles. They may take 500 to 1,000 in
9 aircraft.

10 MR. WOOD: Aircraft, yes.

11 MEMBER SIEBER: You do one thing to one
12 person at a nuclear power plant and that changes your
13 value system.

14 MR. WOOD: And we did look at like braking
15 systems and other things in automobiles to see if
16 diversity was used and didn't find specific instances
17 of that.

18 MEMBER SIEBER: Right. On the other hand,
19 the fact that the public and the law, our law, is
20 sensitive to danger to people from this industry, that
21 increases the demand for diversity over and above what
22 you would find in other industries.

23 MR. WOOD: The guidance that we cited for
24 the chemical industry came about as guidance in
25 response to calls for regulatory oversight after the

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1 Bho Pal incident.

2 MR. HECHT: Mike, can I ask a question
3 about basically you're weighting on the basis of
4 industrial experience. But earlier here on chart 18
5 you have some very interesting data related to the
6 relative proportion of I guess --

7 MR. WATERMAN: Defects. Common defects.

8 MR. HECHT: Yes, of common defects or
9 basically important defects. Why did you choose the
10 industrial rating rather than just using the defects
11 weighting?

12 MR. WATERMAN: Because the industry itself
13 was struggling with this issue back when we started
14 this research. None of that had been done at the
15 time. And we felt, and I think the ACRS supported the
16 approach, that we ought to take a look at what the
17 rest of the world is doing. And so that's what we
18 did, is we went out and we wanted to see what experts
19 in other industries, how they approached this whole
20 idea of how much diversity is enough. We wanted to
21 look at what evolutionary nuclear power plants who had
22 a lot of digital systems going and how were they
23 approaching it? And our nuclear industry didn't
24 really have a lot of experience in the safety arena
25 with digital systems being backed up by analog

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1 systems. They had some, but we just felt we needed to
2 look outside the industry to get a clearer more global
3 perspective, if you will, on this.

4 MR. WOOD: There's actually another
5 consideration to that. Those defects that had been
6 reported are what you're seeing and the response
7 typically to those is to improve your design.
8 Diversity is really there for the things that you
9 haven't seen but anticipate might be there. And so
10 basing the decision making tool on what you've seen
11 leaves you wide open to the things you haven't seen,
12 the unknown unknowns.

13 MR. HECHT: Well, that's always the case
14 no matter what decision you make. But I would just
15 say that you've made the comment earlier, and that's
16 been reflected also in here, that the aerospace
17 industry has different, not only constraints, but they
18 also have different failure modes. And the same thing
19 would be true of other transportation industries.
20 Even here, what I saw on slide 47, a lot of that
21 seemed to be nuclear industry. NPPs in other
22 countries seems to be the dominant shade on there,
23 pink.

24 MR. WATERMAN: Well, the shading is not
25 pink because it's nuclear power plants.

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1 MR. HECHT: Yes.

2 MR. WATERMAN: The shading was pink by my
3 choice.

4 MR. HECHT: Right, I understand. But the
5 point is that that seems to be where most of your
6 experience is coming from, so implicit in that is the
7 fact that people that you're using data based on what
8 other people have seen and how they've responded. It
9 could be that, if you will, I don't know much you gain
10 from adding yet more multiplications and
11 normalizations. Including a third factor just based
12 on the experience becomes an important thing to
13 consider. Because one of the things that I see in
14 this chart; and by the way, this is common with space,
15 is incorrect parameter values. One of the things that
16 you spend more time on at any point prior to launch,
17 and this is where people spend a lot of time, is the
18 40,000 or 50,000 parameters that go into the launch
19 vehicle, making sure that they're all exactly right.

20 CHAIRMAN APOSTOLAKIS: Forty-thousand,
21 Myron?

22 MR. HECHT: Yes. Yes, I was amazed.

23 CHAIRMAN APOSTOLAKIS: Well, I am, too.
24 Gee, 40,000.

25 MR. WOOD: By comparison, nuclear power

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1 plants are very simple, well-behaved things.

2 MR. HECHT: yes, it keeps a good portion
3 of the overhead paid so that people like us can mess
4 around.

5 But that's reflected here. That's this
6 peak right there. So I guess my point is that if
7 parameters are the major issue here, then anything you
8 do in terms of an alternative life cycle process or a
9 different manufacturing process would not be relevant.

10

11 MR. WATERMAN: I don't follow that, Myron,
12 it wouldn't be relevant.

13 MR. HECHT: Well, let's just say that you
14 have one version implemented in eta and another
15 version implemented in C, and they're both dependent
16 on the same parameter database, then the diversity
17 that you might get or the score that you might get for
18 that eta and C, which might take you over a threshold,
19 actually is less effective in this application domain.

20 MR. WOOD: Or for that specific common-
21 cause failure instance I would agree that there would
22 be perhaps some design approaches and some other
23 diversity attributes that would be effective whereas
24 different software implementations would be. I would
25 agree. But we tried to factor those things in. In

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1 chapter 6 of the report it goes through each diversity
2 and talks about what is that diversity's impact on
3 these sources of common-cause failure, these triggers
4 of common-cause failure, these locations of common
5 cause failure.

6 So the tie to the experience is two-fold.

7 One is through the approaches that have proven
8 effective in the international plants that have a
9 significant amount of digital systems used. And the
10 other is through the rationale used in determining the
11 effectiveness of different diversity applications.

12 MR. HECHT: Okay. But what you're really
13 selling here is you're selling a score, you know, kind
14 of like a FICO score on a credit report or something
15 like that, right?

16 MR. WATERMAN: Well, what we're trying to
17 sell, if you will, is a metric for evaluating
18 diversity approaches.

19 MR. HECHT: Okay. I call it a score,
20 which it's easier for me to --

21 MR. WATERMAN: I'll use George's
22 definition. It probably sounds better.

23 MR. HECHT: Okay. Fine. That metric.

24 MR. WOOD: I like to look at the score and
25 the tool that gives the score as a way of informing

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1 your decision, but not the sole basis of your
2 decision.

3 MR. HECHT: Okay. Well, I guess the point
4 is that once you look at a number like that, a number
5 has a compelling value and the reason why I use the
6 word "score" is precisely because, you know, you want
7 to determine whether you've won the game. So if you
8 say this score is only a partial weight and you also
9 have to consider the application of the particular
10 diversity problem that you're addressing, then why not
11 take it one step further and say include that
12 particular problem that you're addressing in the way,
13 or in the metric?

14 MR. WATERMAN: The particular problem
15 you're addressing determines whether or not you need
16 diversity.

17 MR. HECHT: All right.

18 MR. WATERMAN: What this does is assesses
19 once you've determined that need, okay --

20 MR. HECHT: Fair enough.

21 MR. WATERMAN: -- and you've designed to
22 address that need, have you really hit all the things
23 you need to hit?

24 MR. HECHT: Okay.

25 MR. WATERMAN: Okay. You're getting into

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1 need again, and I don't want to get into need. We've
2 already done the research on that. We got a
3 regulation that says sometimes it's needed. You have
4 to determine where it's needed. None of this research
5 identifies that, but this research identifies it as
6 once that need has been determined, by whatever
7 process is used, how much diversity is enough? And
8 when a design is proposed so that we can evaluate a
9 design, do a quick screen and then dig into the design
10 to make sure all the things that are credited are
11 really there.

12 MR. HECHT: Okay.

13 MR. WATERMAN: They're appropriate.

14 MR. HECHT: You've said that, or I think
15 what you basically said is that because BTP 7-19, that
16 filter has pretty much eliminated the question of need
17 and --

18 MR. WATERMAN: In some applications, not
19 all.

20 MR. HECHT: Okay. All right. So like I
21 said, that was the point. I'm not sure that can
22 completely get away from that even afterwards.

23 MR. WATERMAN: Okay.

24 CHAIRMAN APOSTOLAKIS: Shall we move on
25 beyond slide 26? I think we beat that to death.

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1 MR. WATERMAN: And slide 27 just broke it
2 out by various attributes. A very busy slide, you
3 know? Okay. That's the data.

4 CHAIRMAN APOSTOLAKIS: So what is the
5 message here?

6 MR. WATERMAN: It just shows some of the
7 results of the data. There's no big message there.

8 CHAIRMAN APOSTOLAKIS: So it's the
9 percentages in terms of --

10 MR. WOOD: We've seen instances of each
11 criterion being employed.

12 CHAIRMAN APOSTOLAKIS: Right. Right.

13 MEMBER BROWN: And it's not concentrated.
14 If you look at this, it's not concentrated in one
15 particular --

16 MR. WOOD: There's no magic bullet.

17 MEMBER BROWN: There's 20 different, or
18 whatever the number is, and it's a relatively --

19 CHAIRMAN APOSTOLAKIS: And most of them
20 are low now, two, three, four percent.

21 MEMBER BROWN: Sure.

22 CHAIRMAN APOSTOLAKIS: Different logic
23 processing versions in same equipment architectural,
24 zero.

25 MR. WATERMAN: Yes, didn't seem to see any

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1 -- let's see here. I can't hardly read it.

2 CHAIRMAN APOSTOLAKIS: Oh, well it is on
3 the right.

4 MR. WATERMAN: Yes, I see where it is.

5 PARTICIPANT: It's a blue box.

6 MR. WATERMAN: Yes. It's one of the blue
7 ones, yes. It's different logic processing versions
8 in same equipment architecture. Somebody using an
9 Intel and a Pentium. There are different versions
10 made by the same manufacturer to get diversity. We
11 just didn't see any cases where people opted for 486s
12 and 286s or --

13 MR. WOOD: We did see one instance in
14 aerospace in an Airbus application where they used I
15 think a 286 and then a 386, but because of the context
16 considerations, that was screened out as a tool.

17 MR. WATERMAN: This is the data that went
18 into developing the weights.

19 CHAIRMAN APOSTOLAKIS: I mean, what
20 impresses me here is these very low numbers.

21 MR. WATERMAN: Add them up. They add up
22 to 100.

23 CHAIRMAN APOSTOLAKIS: No. Yes, but, I
24 mean one or two, three, four percent. There doesn't
25 seem to be something that most people seem to like.

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1 Is there a message here or am I missing --

2 MR. WATERMAN: I think the message here is
3 that --

4 CHAIRMAN APOSTOLAKIS: What is the
5 message?

6 MEMBER BROWN: The message is it's not
7 clear.

8 MR. WATERMAN: No, I think there's another
9 message here.

10 MEMBER BROWN: It's not clear.

11 CHAIRMAN APOSTOLAKIS: Well, I understand
12 that, but I mean --

13 MR. WATERMAN: I think the message that
14 really comes through loud and clear here is that just
15 selecting one of these is probably not going to be
16 enough. The real diversity approach takes advantage
17 of a lot of different criteria in a particular
18 combination to address a set of common-cause failures.

19 CHAIRMAN APOSTOLAKIS: Well, look at
20 the --

21 MR. WATERMAN: We had the software
22 languages thing here, six percent. What that six
23 percent represents is that if somebody just wanted to
24 go with different software languages, you'd get a
25 score of maybe six percent or nine percent, or

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1 something like that where you apply all the attribute
2 weights, right?

3 CHAIRMAN APOSTOLAKIS: Different
4 algorithms logic --

5 MR. WATERMAN: So if somebody says, yes,
6 my diversity involves I'm using C instead of eta 85 or
7 whatever, some other language. You know, I'm using
8 that and therefore I have enough diversity. Well, if
9 go look at this kind of information here, you go, wow,
10 that doesn't seem diverse to me. What are you doing
11 about functional diversity, you know? What if you got
12 the wrong requirements and you're just programming the
13 wrong requirements in two languages? You haven't
14 addressed diversity at all.

15 MEMBER BLEY: The troubling thing here for
16 me is that these tell us the variety of things people
17 are doing, have tried and they don't tell us anything
18 about how effective they were or are they repeating
19 these and continued applications, or in one area? Are
20 they using six of these or two of them? It's just a
21 count. And I have real trouble seeing how that
22 relates to any measure of goodness or effectiveness.

23 MEMBER BROWN: The other thing it doesn't
24 show is, you know, did you start out, you know, 20
25 years ago using software -- down and some of those

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1 have been thrown away and people aren't doing them
2 anymore.

3 MR. WOOD: We looked at it some in the --

4 MEMBER BLEY: Since this is just the total
5 for all time.

6 MR. WOOD: We looked at it for the Airbus
7 because you had a progression of examples. We looked
8 at it in the nuclear industry because we had an
9 evolution of starting -- I guess Darlington may have
10 been one of the earliest examples we used. And then
11 through Sizewell and then to Olkiluoto and Lungmen as
12 the current examples. So we did look at things. What
13 we didn't see is a narrowing down to a limited set of
14 responses or application of diversity. We saw still a
15 multi-faceted use of diversity in most applications.

16 MR. WATERMAN: There are a couple of
17 things with time experiences. The diverse systems
18 that go in are going in to handle an unusual accident.

19 So you don't see a lot of challenges where they
20 actually have to respond to anything. The other area
21 you see is that the fact that we go out and we collect
22 this data from plants, if the systems weren't very
23 diverse or weren't very affected, they would have
24 changed them. Right? Until they get something that
25 works for them, and that's reflected in the data that

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1 we gathered. This isn't theoretical stuff. This is
2 we went out and looked at what are people using? And
3 remember the assumptions are was that there was
4 engineering judgment applied in the application of
5 those particular diversity strategies along with cost
6 benefit, operating experience and things like that.
7 The fact that they actually exist in plants and exist
8 in different industries and also that they're
9 addressed in different positions by agencies and
10 organizations reflects some judgment went into
11 actually selecting those particular combinations of
12 diversity attributes --

13 MEMBER BLEY: I guess what I don't see is
14 a place here where -- I don't know anything else you
15 could have done, where you've applied your judgment of
16 yes, seeing people have used these, I know a little
17 bit about how effective they are, I don't, but where
18 you overlay on that your knowledge of our systems and
19 some measure of -- usually we like to see something on
20 risk-informed, performance-based, something about is
21 there performance, anything about this related to our
22 industry that would tell us one of these is any better
23 than any other in particular applications?

24 MR. WATERMAN: Well, you can pull example
25 systems out of the U.S. we applied after the fact.

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1 Actually use sort of benchmarks of, you know, what are
2 we doing. These systems have been approved. This is
3 -- forgive me, this is an ATWS, generic ATWS, as we've
4 been told not to mention ATWS because -- but this is
5 just a generic ATWS system of one particular vendor
6 design. Went into the technical information, dug out
7 all of the features that they use in the ATWS system,
8 stuck it into that little tool I described and it
9 calculates up I think at 1.01 or something like that,
10 Some value like that, which gave me some reasonable
11 assurance that here's a system that the NRC reviewed,
12 licensees have applied and we found it acceptable.
13 And how does it score out and --

14 MEMBER BLEY: They're using the same kind
15 of things that other people are using.

16 MR. WATERMAN: Right. And this here is
17 the Oconee diverse low-pressure injection actuation
18 system scored out. Okay? And it's well within this
19 pink region of warm, fuzzy feeling about, you know, is
20 it really important?

21 MEMBER BLEY: Right.

22 MR. WATERMAN: Of course we reviewed that
23 one. So an answer to your question is, is this stuff
24 applicable to the U.S. industry? It would appear just
25 from these limited examples, yes, it can.

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1 MEMBER STETKAR: But, Mike, this still
2 comes back to you assigned weights to each of those
3 seven attributes based on what the world, an amalgam
4 of a mushy world, has done.

5 MR. WATERMAN: Full of experts and
6 people --

7 MEMBER STETKAR: No, no, no. An amalgam
8 of a mushy world has done. Suppose, for example, that
9 the Ocone engineers thought about a specific set of
10 common-cause failure modes and made the determination
11 that all three specific attributes were the most
12 important ways to address those failure modes. So
13 they effectively discounted the other four, the work
14 that the amalgam of the mushy world has done and they
15 assigned, you know, 33 percent weight --

16 MR. WATERMAN: They can't find a weight.
17 What are you saying?

18 MEMBER STETKAR: No, no. You've assigned
19 the weight based on the multi-amalgam and I'm saying
20 that weight doesn't mean anything to me. If I always
21 leave my driveway and turn left because I'm worried
22 about a common-cause failure to the right side of my
23 street, you would identify turning out of the driveway
24 as something that a technology always does. That's
25 mean my practice applies to a nuclear power plant.

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1 It's just my decision for my particular common cause
2 on my street. I wouldn't assign that a weight of
3 anything to a nuclear power plant and yet I might
4 assign it a weight of 100 percent, the most effective
5 technology that I could use in my particular
6 application to battle that common cause.

7 MEMBER BROWN: Unless your neighbor parked
8 their car on the other side.

9 MEMBER STETKAR: All right. Yes, that's
10 variability. But my point is that assigning pre-
11 defined weights to the attributes as if they are
12 universally applicable to any industry and any common-
13 cause failure mode constrains that number. It means
14 that comparing that nice 1.01 for the one bar to the,
15 you know, .895 or .925, or whatever the heck it is for
16 the other bar, doesn't mean anything because you're
17 looking at the problem from a different -- you're
18 trying to protect perhaps against different types of
19 common-cause failure modes.

20 But I finally see where you're going with
21 this thing. What I'm concerned about is the a priori
22 numerical weights for the seven attributes.

23 MEMBER BROWN: Just a question. Why is
24 that any different than -- and I don't know if this is
25 the right analogy or not; I understand the point and I

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1 actually agree with you. But when you look at a PRA
2 world and you look at the assignments of probabilities
3 to some of the events in the trees that are developed,
4 low numbers, and try to come up with a basis for ten
5 to the minus six or ten to the minus four --

6 MEMBER STETKAR: Oh, looking for a valve
7 failing?

8 MEMBER BROWN: I don't agree with that. I
9 think there's a relationship there when you're making
10 a judgment, you're using a judgment.

11 MEMBER STETKAR: Because I'm not making a
12 judgment about the valve.

13 MEMBER BROWN: Oh, well you know the
14 population of all the valves in the entire industry
15 and how many have failed each year and under what
16 circumstances, and this has been calculated out?

17 MEMBER STETKAR: Yes, but I'm not using
18 pump data for that valve as a generic piece of
19 equipment.

20 MEMBER BROWN: Well, I agree. I agree
21 with that.

22 CHAIRMAN APOSTOLAKIS: You are not using
23 valve data from some industry that has nothing to do
24 with nuclear.

25 MEMBER BLEY: Or even pump data or logic

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1 card data, which is --

2 CHAIRMAN APOSTOLAKIS: Well, but I mean,
3 this is a perennial problem it seems to me of the
4 generic information's applicability to a specific --
5 which comes back to Sergio's comment earlier, it seems
6 to me. If I had a pie chart like this from high-
7 hazard industries, ideally only from nuclear, then
8 this would be much more meaningful.

9 MEMBER STETKAR: I was sitting here and
10 because of the time, I was starting to draw an analogy
11 to some of the stuff that some human reliability
12 methods use. If you think of these as performance
13 shaping factors and for a particular human performance
14 scenario certain performance-shaping factors are more
15 important than others. The time may be more important
16 than the availability of procedures, for example.
17 Man-machine interface might be more or less important.

18 That's a scenario specific. The weights that you
19 assign to those performance-shaping factors vary given
20 the context of the scenario. So they're not fixed
21 weights.

22 Now within each performance-shaping
23 factor, you may have different attributes which you
24 haven't even gotten there yet. You know, your
25 different rankings of the effectiveness within each of

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1 those categories. Those might be relatively fixed.

2 MEMBER SIEBER: Yes, on the other hand
3 there's no way for the staff to reach a conclusion
4 without putting numerical values on these things,
5 whether they're right or wrong. I mean, to me I
6 consider this just an advancement.

7 CHAIRMAN APOSTOLAKIS: I really think it
8 comes down to whether you can take the information
9 from all industries. Because look at this purple on
10 27, slide 27, because that tells me a lot. It's one
11 of the higher numbers, is different reactor or process
12 parameter sensed by different physical effects? Eight
13 percent.

14 MR. WATERMAN: Sure.

15 CHAIRMAN APOSTOLAKIS: The reason it's
16 eight is if you did it only for the nuclear industry,
17 that would be very high. The reason why it's eight is
18 because the other stuff pulls it down.

19 MR. WOOD: Actually no, it's very high
20 because of nuclear.

21 CHAIRMAN APOSTOLAKIS: And I think that is
22 along the lines of John's comment and back to
23 Sergio's. In other words, I know that in the nuclear
24 industry we use a multiplicity of parameters to
25 monitor and all that. I know. I mean, if I limit

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1 myself to nuclear, that would be, I don't know, 90
2 percent or something. It's eight. It still stands
3 out, because everybody else is two and three. But the
4 reason why it's eight is because the denominator is
5 artificially large.

6 MEMBER BROWN: I think he's going to
7 disagree with you, yes.

8 CHAIRMAN APOSTOLAKIS: Well --

9 MEMBER BROWN: No, he just said -- go
10 ahead.

11 MR. WOOD: The nuclear industry has the
12 most predominant use of alternate measurements.

13 CHAIRMAN APOSTOLAKIS: Right.

14 MR. WOOD: Because of the application of
15 functional diversity --

16 CHAIRMAN APOSTOLAKIS: Right. Right.

17 MR. WOOD: -- compounded with signal
18 diversity. And those have a heritage in some of the
19 traditional approaches to diversity that derive from
20 the general design criteria and are not specific to
21 digital or --

22 CHAIRMAN APOSTOLAKIS: That's true.
23 Absolutely. Yes. Yes.

24 MR. WOOD: Some of the other industries
25 that were factored out don't have signal diversity

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1 because they're limited on the sensors that they can
2 apply. The chemical industry does highly recommend
3 different measurements to support the decisions for
4 shutting down different reactions or chemical
5 processes. So I think the industries that were
6 included that are not nuclear have more in common with
7 nuclear power than the ones that were excluded and
8 don't use some of the diversities that were seen.

9 MEMBER BONACA: I got to understand one
10 number. still don't understand it, so take the box on
11 the left. Different manufacturers, fundamentally
12 different equipment designs, two percent. What does
13 it mean, two percent? Could you explain to me? Does
14 it mean that the diversity has been improved by two
15 percent?

16 MEMBER BROWN: No, only two percent of the
17 people have taken that approach.

18 MEMBER BLEY: Can I try to see if I
19 understand it?

20 MEMBER BONACA: And I would like to have
21 an answer.

22 CHAIRMAN APOSTOLAKIS: Only two percent
23 are using it. I think that's what it means.

24 MR. WATERMAN: Of your average strategy
25 that might make up the two percent.

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1 MEMBER BONACA: Okay. All right.

2 MR. WOOD: And that's related to how many
3 instances where different manufacturers supplied.
4 It's constrained by other instances where the same
5 manufacturer provided a diverse system.

6 MEMBER BROWN: That's another box in here
7 though.

8 MR. WATERMAN: So there are some inter-
9 relations among the attributes.

10 MEMBER BLEY: I want to really understand
11 this one because I kind of lost it twice. When you
12 looked at all the different industries, you kind of
13 counted up out of all of these things they could do,
14 they either do them or they don't them. If they do
15 them, you counted it.

16 MR. WATERMAN: Yes.

17 MEMBER BLEY: You didn't have any kind of
18 count of how many times they do these things.

19 MR. WATERMAN: No.

20 MEMBER BLEY: It was just industry A uses
21 10 of these, something like that?

22 MR. WATERMAN: Well, yes, in a way you --

23 MEMBER BLEY: And then you had a total of
24 all the industries that were whatever number.

25 MR. WATERMAN: Actually, that was --

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1 MEMBER BLEY: This is a fraction of the
2 industries that used these particular --

3 MR. WATERMAN: For developing the weights,
4 I only used those industries and positions and plants
5 that were between the red lines.

6 MEMBER BLEY: Right.

7 MR. WATERMAN: We screened out the other
8 stuff there. And then we took an aggregate of those,
9 if you will, for determining well, what's the average
10 usage on design diversity? What's the average usage
11 on, you know, each of those attributes and scored it
12 out and --

13 MEMBER BLEY: But each industry kind of
14 gets one count for each of these things.

15 MR. WATERMAN: Yes, but I think we're
16 getting wrapped around the axle about numbers in the
17 second decimal. Right? And we're getting wrapped
18 around the axle about 1.01 versus .94, when really
19 what the metric says is, is it good enough? Right?
20 Does it matter if it's one or .94? Not really,
21 because does it address the common cause?

22 MEMBER BLEY: I don't think that's where
23 we're hung. We're --

24 MR. WATERMAN: Well, that's what I'm
25 getting is --

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1 MEMBER BLEY: -- hung up somewhere else.

2 MR. WATERMAN: Yes.

3 MEMBER STETKAR: Mike, let me make sure I
4 understand. When you were talking about different
5 industries as if you have thousands of sample points.
6 The railroad industry has precisely three things that
7 you looked at.

8 MR. WATERMAN: Yes.

9 MEMBER STETKAR: The aerospace industry
10 has two.

11 MEMBER BLEY: But they're not inside the
12 red line.

13 PARTICIPANT: Four.

14 MEMBER STETKAR: Four. Okay.

15 MR. WATERMAN: But yes, I know what you
16 mean, is they --

17 MEMBER STETKAR: Well, so those two
18 percents and one percents are sort of fractions of a
19 population of --

20 MR. WATERMAN: Of a small population.
21 Really a small population.

22 MEMBER STETKAR: -- that's highly weighted
23 toward the nuclear business because they have about, I
24 don't know, 12.

25 MR. WATERMAN: Since that's where we're

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1 trying to, you know, apply this, yes.

2 CHAIRMAN APOSTOLAKIS: One other thing
3 that I think you had discussed but I want to make
4 clear for me, when Dennis raised the issue of
5 effectiveness, I think part of your answer was, well,
6 one of the reasons they are using it is because they
7 have judged it to be effective. In other words,
8 effectiveness is to some degree included in these
9 numbers.

10 MEMBER BLEY: That seems to be the crux of
11 the argument here.

12 CHAIRMAN APOSTOLAKIS: Right.

13 MEMBER BLEY: These are done by smart
14 people who probably are going --

15 CHAIRMAN APOSTOLAKIS: Who have already
16 decided that this is --

17 MEMBER BLEY: So that's our basis for
18 thinking it's a reasonable thing.

19 CHAIRMAN APOSTOLAKIS: Okay. Okay. Good.

20 MEMBER BLEY: That's correct.

21 MR. WATERMAN: Well, that's why I brought
22 to you guys.

23 CHAIRMAN APOSTOLAKIS: I think --

24 MR. WATERMAN: I'm going after more smart
25 people.

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1 CHAIRMAN APOSTOLAKIS: I think -- yes?
2 What? Oh, I'm sorry. Ray.

3 MR. TOROK: Just a little --

4 CHAIRMAN APOSTOLAKIS: Identify.

5 MR. TOROK: Oh, I'm sorry. I'm Ray Torok
6 from EPRI. I just wanted to offer a little
7 clarification, maybe a suggestion. If we go back to
8 Mike's slide 18, which is the one where Mike looked at
9 the OE evaluations we did and showed how they fit into
10 the wheel there.

11 CHAIRMAN APOSTOLAKIS: Okay.

12 MR. TOROK: One of the thing that's
13 interesting to note there is that if you add up all
14 those orange bars, it shows that for the NRC industry
15 experience that we were looking at, those things
16 dominate. And so if you're talking about diversity
17 measures or other kinds of measures that go after
18 those things, then it shows, you know, what is
19 probably of value in the nuclear industry. It's
20 roughly two-thirds of it.

21 Now if and when we come back later, we can
22 talk more about that, why it comes out that way based
23 on the OE and so on, but I don't want to take any more
24 time right now. Thanks.

25 CHAIRMAN APOSTOLAKIS: You will come back

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1 later.

2 MR. WATERMAN: Thanks, Ray.

3 CHAIRMAN APOSTOLAKIS: You can request the
4 time and it has been granted.

5 MR. WOOD: When we gathered the data, the
6 usage of the data was to inform the development of
7 some strategies. Concurrently, the tool was developed
8 as a way of systematically looking at and comparing a
9 proposed strategy to examples that were chosen that
10 were representative. But also, baseline strategies
11 that were developed based on the understandings
12 derived from the examples and also of engineering
13 judgment on how effective or what's the effect of
14 different diversities. So in chapter 6 there are 10
15 baseline strategies grouped in three families. And
16 one approach is to adopt one of those strategies and
17 they'll show up very high for the tool.

18 Another approach is to use the tool to
19 help inform your design and then the staff can use the
20 tool to determine whether or not it fits within this
21 region of acceptability and that helps them understand
22 how much more detail they need to investigate.

23 CHAIRMAN APOSTOLAKIS: I think that maybe
24 we should move on. But seems to me a lot of the
25 questions have to do with how you plan to use this.

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1 And especially, you know, since this is generic
2 information, at which point in your decision making
3 process do you bring into that process the fact that
4 you are dealing with a specific system in a nuclear
5 power plant. So I get this generic, you know, .95
6 that Mike mentions, .98. I will not forget that this
7 is generic.

8 Now what do I do to make sure that the
9 conclusions I'm going to draw and the decision I'm
10 going to make is in fact system-specific? So that, I
11 think, would be a very crucial step in the
12 methodology.

13 MR. WATERMAN: That was probably on slide
14 47 or --

15 CHAIRMAN APOSTOLAKIS: Well, we're still
16 on 27, so in 20 slides we're going to get that answer.

17 MR. WATERMAN: Yes.

18 CHAIRMAN APOSTOLAKIS: Very good. So move
19 onto 28 then. How about that? Is this running it
20 with an iron hand, or not? I'm asking you. I'm
21 asking you.

22 MR. WATERMAN: So what kind of weights
23 have we got here? We've already hammered on this. We
24 have diversity criterion effectiveness weight, which
25 represents the criterion's relative effectiveness

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1 within the diversity attribute. And we use the
2 NUREG/CR-6303 guidance as a basis for the attributes
3 we've put in there.

4 MEMBER STETKAR: I have to admit I didn't
5 read NUREG/CR-6303. Did they weight things just
6 qualitatively A, B, C or did they --

7 MR. WATERMAN: Yes.

8 MEMBER STETKAR: You assigned the numbers?

9 MR. WATERMAN: And I assigned the numbers,
10 because I was looking for a way of -- on the
11 strategies that were developed in the research, I
12 wanted some way of saying well, did that really
13 capture the conclusions appropriately?

14 MEMBER STETKAR: They rank ordered them,
15 but you assigned --

16 MR. WATERMAN: They rank ordered them.
17 They said this is more effective than this, which is
18 more effective than this.

19 MEMBER STETKAR: Thanks.

20 MR. WATERMAN: And so forth and so on.
21 And we'll talk about my assumptions and the way I did
22 that, yes.

23 MEMBER STETKAR: Okay.

24 MR. WATERMAN: The diversity attribute
25 effectiveness weight represents attribute

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1 effectiveness. That's design, function, equipment
2 manufacturer, etcetera based on operating experience,
3 engineering judgment and positions of other
4 organizations, industries and countries and the
5 standards, and common position. And if you will, that
6 weight was derived from a frequency of usage weight.
7 Okay? We looked at how often is this particular
8 attribute used? How often is this particular
9 attribute used?

10 And while not absolutely true, the
11 criterion effectiveness and the attribute
12 effectiveness are relatively orthogonal such that both
13 weights could be applied multiplicatively. In other
14 words, the DAE, the diversity attribute effectiveness,
15 if you will, modifies the value of the diversity
16 criteria effectiveness for those criteria that are
17 used in particular strategies, keeping in mind that
18 the intention is to use this as a screening too. I
19 don't care whether the value is 1.01 or 1.03. I just
20 want to know is the value within a range of
21 reasonableness for what we would expect.

22 Now, the diversity criterion effectiveness
23 assumptions are first that the criteria within a
24 diversity attribute can be weighted according to the
25 ordering of the criteria within that diversity

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1 attribute. That came out of NUREG/CR-6303 where they
2 said this criterion is more effective than this one.
3 We read through those criterion. It seemed like we
4 didn't have any bones to pick about their assumption,
5 you know, that different technologies for diversity
6 tend to be a little bit more effective than using just
7 digital technology to back up digital technology,
8 using FPGAs to back up microprocessors would appear to
9 be a more effective approach than using AMDs to
10 backup, that type of thing.

11 MEMBER BLEY: I'm not quite sure how or
12 why -- when do you need to need to claim it and how in
13 the world can you even make the claim that those two
14 effectiveness measures are orthogonal?

15 MR. WATERMAN: I said relatively
16 orthogonal.

17 MEMBER BLEY: Based on the argument you
18 made about the diversity attribute effectiveness
19 weight, being that these experienced people applying
20 judgment are using suitable and effective systems has
21 probably got the same judgments in there that we have
22 in the other set of weights out of 6303. There are
23 different levels, I'll acknowledge that, but that
24 they're orthogonal just seems -- do you need that
25 assumption for any reason?

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1 MR. WATERMAN: Well, I think you do if
2 you're going to multiply them together.

3 MEMBER BLEY: If you do, I think that's
4 hard to claim.

5 MR. GUARRO: If they are hierarchical. In
6 other words, the first set of weights is applied to
7 the broad categories and the second to the
8 subcategories. They don't need to be orthogonal, just
9 the different -- I think that's what you're seeing.

10 MEMBER BLEY: That's what I think.

11 MR. WATERMAN: Okay.

12 MEMBER BLEY: But, you know, I'm not sure
13 what this measure really means. But you are
14 multiplying.

15 MR. WATERMAN: Well, the criterion
16 effectiveness simply says how effective is this
17 particular criterion relative to the other criterion.
18 It has nothing to do with what the world does with
19 it.

20 MEMBER BLEY: That makes --

21 MR. WATERMAN: The design -- wait. No,
22 just a second.

23 MEMBER BLEY: I don't think that's true.

24 MR. WATERMAN: You don't think it's --
25 okay. Let's --

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1 MEMBER BLEY: I think the world does with
2 it --

3 MR. WATERMAN: I think we're ready to get
4 into a really lively discussion here. What you're
5 saying is that despite --

6 MEMBER BLEY: If those guys are really
7 smart, it does.

8 MR. WATERMAN: Yes, they're really smart,
9 but it has nothing to do with is analog backing up
10 digital more effective than FPBs backing up Intels.

11 MEMBER BLEY: Sure it does.

12 MR. WATERMAN: Okay. Then it doesn't
13 matter whether the world uses it or not, does it? It
14 is more effective, and so I can weight one over the
15 other. Right?

16 MEMBER BLEY: If you believe that.

17 MR. WATERMAN: If you believe that. Well,
18 I believe that.

19 MEMBER BLEY: But if you believe that the
20 industries are doing it on a logical and smart basis,
21 then I don't see how the orthogonal would be the same.

22 MR. WATERMAN: Well, scratch the
23 orthogonal. What I'm trying to say is that the
24 diversity criterion effectiveness weights are
25 measuring something different than the attribute

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1 weight measured. The attribute weight simply says how
2 many people are using design as an approach toward
3 diversity?

4 MEMBER BLEY: I'm just going to say this
5 once more and then I won't --

6 MR. WATERMAN: Okay. Okay.

7 MEMBER BLEY: But we've argued that that's
8 a useful measure because the people making those
9 decisions can understand they're picking things that
10 are effective in each of their experiences, I think.

11 MR. WATERMAN: Yes.

12 MEMBER BLEY: So I don't seem them as
13 really -- but let's go ahead.

14 CHAIRMAN APOSTOLAKIS: What's an FPGA,
15 Mike?

16 MR. WATERMAN: FPGA is a field-
17 programmable gate array. Thanks. And a field-
18 programmable gate array is a different way of
19 instantiating digital logic. It's a different type of
20 complex electronic --

21 MEMBER BROWN: Like that word,
22 "instantiating?"

23 CHAIRMAN APOSTOLAKIS: I don't understand.

24 MEMBER BROWN: Yes, that's because nobody
25 else does either. Software engineers love that word.

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1 I've sat through more --

2 CHAIRMAN APOSTOLAKIS: Stantiate?

3 MEMBER BROWN: They stantiate everything.

4 MR. WATERMAN: The real answer here is an
5 FPGA is effectively hardware logic. It's
6 combinational logic as opposed to microprocessors
7 which have software logic. If you're running a
8 program, a step program where you're looking at memory
9 and pulling stuff out, all you've done is take
10 individual transistors that you would burn to make a
11 logic diagram. You put it on a chip in an FPGA and
12 you cut lines to make sure you now have that hardware
13 logic burned in. It's not software. So it's really
14 an analog system once you've done it. Now if you can
15 program it separately and un-program it, that's
16 another issue you have to deal with. Some of them you
17 build, once you burn it, it's burned.

18 MR. WOOD: FPGAs don't necessarily have to
19 become notarial logic. They can include --

20 MEMBER BROWN: But it's still more of an
21 analog approach because it doesn't change all the
22 time. And we can argue about that. I was just trying
23 to --

24 MR. WATERMAN: The way I look at it in
25 layman's terms is a microprocessor fetches data,

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1 fetches instructions, does the instruction on the
2 data, stores the result and repeats. And that's how
3 it goes through its process. An FPGA, the data comes
4 through the FPGA and the data flows simultaneously
5 through the FPGA without any fetch instructions,
6 without any fetching data or anything else like that.

7 And what comes out the other side is either a zero or
8 a one, that tells something to trip. They're
9 different animals. That's very simplistic and an FPGA
10 expert would probably --

11 CHAIRMAN APOSTOLAKIS: The *Webster's New*
12 *Riverside University Dictionary* does not have the word
13 instantiate.

14 MEMBER BROWN: That's because they made it
15 up.

16 MEMBER BLEY: It came out of the expert
17 systems 20 years ago. And it's a neat word.

18 MEMBER BROWN: What does it mean?

19 MEMBER BLEY: It means you took a concept
20 and you applied it in a particular --

21 MEMBER BROWN: Why don't you just say
22 that?

23 MEMBER BLEY: You are. You're getting old
24 and cranky.

25 MEMBER BROWN: Yes, right. I'm getting

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1 old and cranky. I just hate that stuff.

2 MEMBER BONACA: Well, he's getting the big
3 dictionary now.

4 CHAIRMAN APOSTOLAKIS: Well, if this
5 doesn't have it, then --

6 PARTICIPANT: Wait until you see the next
7 definition.

8 CHAIRMAN APOSTOLAKIS: But we shouldn't
9 complain, because the word "exceedance" does not exist
10 either.

11 PARTICIPANT: Well, it does now.

12 MEMBER BROWN: It's not a word, that's
13 why.

14 MEMBER BLEY: I think English evolves.

15 CHAIRMAN APOSTOLAKIS: Michael, will you
16 please continue?

17 MR. WATERMAN: Thank you.

18 CHAIRMAN APOSTOLAKIS: We are exploring
19 the --

20 MR. HECHT: Why don't you go to Google?

21 CHAIRMAN APOSTOLAKIS: No, no, no.

22 MR. HECHT: Type in the word and --

23 MEMBER BROWN: That's like Wikipedia.
24 It's made up facts. Okay?

25 MR. WATERMAN: Moving right along.

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1 CHAIRMAN APOSTOLAKIS: Yes, moving right
2 along. Yes.

3 MR. WATERMAN: DCE weights are based on
4 the NUREG/CR-6303 relative effectiveness discussions.

5 MEMBER BLEY: I'm sorry. It's in the *OED*.
6 Enough said.

7 MR. WATERMAN: The *OED*.

8 MEMBER BLEY: *Oxford English Dictionary*.
9 It's the authority on the language.

10 CHAIRMAN APOSTOLAKIS: Here it is --

11 MEMBER BLEY: One-oh-six volumes.

12 CHAIRMAN APOSTOLAKIS: Instantiate. To
13 provide the instance of or concrete evidence in
14 support of a theory, concept, claim, or the like.
15 That's what it means.

16 MEMBER BONACA: It doesn't say
17 substantiate. It says --

18 CHAIRMAN APOSTOLAKIS: It says to provide
19 an instance of or concrete evidence in support of a
20 theory, concept, claim, or the like.

21 MEMBER BONACA: Yes, instantiate.

22 MEMBER BLEY: Is that concrete evidence?

23 PARTICIPANT: No, it's an instance that's
24 concrete --

25 MR. WATERMAN: An object --

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1 MEMBER BROWN: Concrete is very firm.

2 MR. WATERMAN: Making something --

3 CHAIRMAN APOSTOLAKIS: Instance of or
4 concrete evidence, yes.

5 MEMBER BROWN: Yes, concrete evidence.
6 That's firm.

7 CHAIRMAN APOSTOLAKIS: What does that have
8 to do with instantiate?

9 PARTICIPANT: Or. Or. There's and "or."
10 So instance of or --

11 CHAIRMAN APOSTOLAKIS: Concrete evidence.
12 Or, O-R.

13 MEMBER STETKAR: George, what does this
14 have to do with DCE weights?

15 CHAIRMAN APOSTOLAKIS: Instantiate is a
16 word that we heard yesterday and today and Charlie
17 said that this word is --

18 MEMBER BROWN: It's just made up.

19 CHAIRMAN APOSTOLAKIS: -- made up.

20 MEMBER BLEY: It's in the *OED*. It means
21 represent as or by an instance.

22 CHAIRMAN APOSTOLAKIS: What, instantiate?

23 MEMBER BLEY: Yes.

24 CHAIRMAN APOSTOLAKIS: Mike, can you go
25 on?

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1 MR. WATERMAN: I'd love to, but I got a
2 note here, never use instantiation.

3 MEMBER BLEY: Oh, please do. You've got
4 half-and-half.

5 MR. WATERMAN: Now, the DCE weights, the
6 criterion effectiveness weights are based upon that
7 discussion in NUREG/CR-6303 about what would be
8 considered more effective than something else, in each
9 of those attributes. And the *95421 relative
10 effectiveness, well we accepted that. I mean, after
11 all we published the NUREG. And that's essentially
12 been accepted by the nuclear industry since it was
13 published in 1994. So, you know, those relative
14 effectiveness things, I felt, well, they've been
15 around for 15 years. It seems like I should be able
16 to, you know, take their word for it that one is more
17 relatively effective than another.

18 And we haven't gone back in and revised
19 that relative effectiveness, so it seemed like, oh,
20 okay, I can use those relative effectivenesses. Now,
21 mind you, when they were described in the NUREG, it
22 was all qualitative discussion. This is more
23 relatively effective? Then how much more relatively?
24 Well, nobody ever defined that. And maybe that would
25 be a good research project.

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1 MEMBER STETKAR: You've never defined how
2 much more relatively more effective. You've said that
3 different logic processing architectures are twice as
4 effective as different compound and integration
5 architecture.

6 MR. WATERMAN: Yes, I've just --

7 MEMBER STETKAR: They're precisely
8 effective.

9 MR. WATERMAN: I'll get into that in a
10 second. Thanks.

11 MEMBER STETKAR: Okay.

12 MR. WATERMAN: Where am I at here? The
13 second assumption was that, okay, if we're going to
14 have weights, they ought to be different for each
15 criterion within the attribute. And the underlying
16 basis for that assumption is that the authors of
17 NUREG/CR-6303 did not ever equate two adjacent
18 criteria within a diversity attribute as being equally
19 effective. It was always this is more effective than
20 this, which is more effective than that. So if we're
21 going to weight those criteria, well it seems like the
22 weights ought to be different, too.

23 And diversity criteria within a diversity
24 can be distributed uniformly according to the order
25 and number of criteria within a diversity attribute.

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1 Okay. I didn't have any data that said
2 different technologies was 27.5 percent more effective
3 than fundamentally different approaches within the
4 same technology. I didn't have any of that
5 information. So I had to make some assumptions.
6 Well, if we're going to weight this, what's an easy
7 way to weight it, keeping in mind that I was going to
8 apply those weights uniformly across the full set of
9 data. Any differences in relative effectiveness,
10 everything would be treated the same. And so that's
11 what I did. And furthermore, I felt that -- yes,
12 John?

13 MEMBER STETKAR: Yes, let me ask you a
14 specific question then. I didn't notice in your
15 handouts. You don't have the table of weights, do
16 you?

17 MR. WATERMAN: Yes. No.

18 MEMBER STETKAR: Okay. Okay. Let me ask
19 you a specific question, because you said you didn't
20 have any evidence. So I'm looking at the design
21 attribute for which you've assigned weights of .5 for
22 different technology, .33 for different approaches --

23 MR. WATERMAN: Three-six-two-six-one-six.

24 MEMBER STETKAR: Three-six-two-six-one-
25 six. Different architectures receives a weight of

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1 .167. I notice though that the infinitely wise people
2 who actually do these things, within the design slice
3 of your pie chart applied different architectures five
4 percent of the time, different approaches within a
5 technology two percent of the time and different
6 technologies two percent of the time, meaning that the
7 people actually doing it have made the decision that
8 different architectures must be more than twice as
9 effective as either of the other attributes.

10 MR. WATERMAN: Within a cost-benefit
11 basis. Maybe part of their decision I'm sure was
12 driven by, well, how much more is it going to cost us
13 to go with completely technology? Well, we can't
14 afford that. Okay. Well, let's take the second
15 alternative.

16 MEMBER STETKAR: Okay.

17 MR. WATERMAN: That's a usage
18 consideration --

19 MEMBER STETKAR: Okay.

20 MR. WATERMAN: -- versus a relative
21 effectiveness.

22 MEMBER STETKAR: But you'd argue that the
23 cost and efficacy and --

24 MR. WATERMAN: Well, I can't control that,
25 you know?

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1 MEMBER STETKAR: Yes.

2 CHAIRMAN APOSTOLAKIS: So, maybe I missed
3 it, the weights you're deriving now, how are they
4 related to the fractions, to the percentages that we
5 saw earlier?

6 MR. WATERMAN: Those percentages were
7 strictly off of what we saw --

8 CHAIRMAN APOSTOLAKIS: Okay. So these are
9 not your own evaluations or judgments?

10 MR. WATERMAN: Yes.

11 CHAIRMAN APOSTOLAKIS: And I was
12 wondering, this is, as we've said many times, this is
13 a judgment thing. One way of structuring the
14 solicitation of judgment is to use methods like the
15 analytic hierarchy process. Have you thought about it
16 at all?

17 MR. WATERMAN: No, I haven't.

18 CHAIRMAN APOSTOLAKIS: Would you like to
19 think about it? Because that helps also when -- it
20 helps you to make self-consistent judgments. And also
21 you can use to elicit the judgments of a number of
22 stakeholders, not just your own. I mean, say Michael
23 and Richard are two stakeholders. Do your own thing
24 and then compare. But you can to other people, too.
25 And that might be a way of addressing questions like

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1 Dennis' regarding orthogonality and Sergio's
2 hierarchy, because it is a hierarchical approach. So,
3 I don't know. Steve, are you familiar with the
4 method?

5 MR. ARNDT: Very much so.

6 CHAIRMAN APOSTOLAKIS: Okay. And you work
7 for this Agency that work for this -- you talk to each
8 other? Just a suggestion. I mean, is what you are
9 presenting cast in stone yet?

10 MR. WOOD: No.

11 CHAIRMAN APOSTOLAKIS: Okay.

12 MR. WOOD: No, this is all still draft
13 stuff and then, you know, the threshold --

14 CHAIRMAN APOSTOLAKIS: Very good. Well,
15 that's the purpose of Subcommittee meetings, actually.

16 MR. WOOD: Okay.

17 CHAIRMAN APOSTOLAKIS: Occasionally be
18 helpful.

19 Okay. Please. I think we should stop
20 here. Take a break. Because this is now our numbers.
21 I mean, quantities. I see plus and minus.

22 MR. WOOD: Only one page. Originally, I
23 was just going to show this equation, not do all the
24 assumptions.

25 CHAIRMAN APOSTOLAKIS: Where are now,

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1 slide 32?

2 MR. WOOD: I'm on 32.

3 CHAIRMAN APOSTOLAKIS: Yes, but that's
4 what you think you're going to do. There may be
5 questions.

6 MR. WOOD: Yes.

7 CHAIRMAN APOSTOLAKIS: So we'll be back at
8 10:15, there about.

9 (Whereupon, at 10:0 a.m. off the record
10 until 10:19 a.m.)

11 CHAIRMAN APOSTOLAKIS: Okay. Are you
12 ready, Mike?

13 We're back in session.

14 Mike, how are you?

15 MR. WATERMAN: I'm great. I'm getting a
16 lot of good feedback here, real positive feedback.

17 CHAIRMAN APOSTOLAKIS: Very good. So
18 then, slide 33.

19 MR. WATERMAN: Before I jump into this
20 slide, I would like to point out that this is still a
21 work in progress. You know, none of this stuff is
22 draconian yet.

23 CHAIRMAN APOSTOLAKIS: No, no. Actually,
24 this is the kind of Subcommittee meeting that most of
25 us like. When you guys are still in the process of

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1 doing things to come here so in case you get some
2 insight or whatever, you will have time to respond. I
3 mean, if you come with a finished product, it's always
4 a problem.

5 MR. WATERMAN: Yes, it certainly is.

6 CHAIRMAN APOSTOLAKIS: So we appreciate
7 your willingness to come while this thing is still
8 evolving. Okay.

9 MR. WATERMAN: And the purpose of this
10 metric; I really like that term, George. The purpose
11 of this metric is that there's a lot of really good
12 engineers out in the industry and each one of them
13 brings their own set of judgments to the table when
14 they're designing a system. And then they submit
15 those systems to the NRC and we have a lot of
16 different judgments within the NRC, even between
17 reviewers. And what I was hoping with this type of a
18 metric would be that we would help reduce that
19 variability and judgment. Because really, when a
20 licensee submits something to the NRC, it really
21 shouldn't matter who's doing the review, right? If
22 you've got two different reviewers, they should both
23 come to the same conclusion. And I'm hoping that this
24 metric will help us arrive at that position such that
25 we do a consistent licensing process and the industry

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1 knows what to expect and then bring in their
2 variability and judgments also.

3 MEMBER BLEY: One thing that's going to be
4 crucial there, I see two applications. If I need some
5 way to get confidence that this measure, metric
6 behaves the way one would like it to behave is really
7 important, after you apply it do the things make sense
8 the way they rank afterwards? Do they stack up the
9 way you think they should? Is it transitive? If you
10 do the evaluations backwards or something, does it
11 come out the same? Things like that.

12 MR. WOOD: Sensitivity studies on the
13 weights would be useful.

14 MEMBER BLEY: I think so. I think you
15 need a probative -- that to gain confidence that when
16 you get results from it, they really mean --

17 MR. WATERMAN: Yes, and that was part of
18 using that ATWS system, because I wanted something
19 that what have we approved, what have we accepted,
20 what are people using out in the industry? How does
21 that stack up against all this metric? And it seemed
22 to stack up like it came out. Well, it's about
23 average.

24 MEMBER BLEY: It would be nice to see
25 something that you didn't approve first. You know,

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1 look at earlier versions in time, see what it looks
2 like with this metric. Was it bad at first and then
3 got better with respect to the metric?

4 MR. WATERMAN: Good point, Dennis. I
5 usually try to do that stuff. Think of what doesn't
6 work and figure out why.

7 Okay. DCE weight. Wow, how did I get to
8 there? Okay. Here we are. This is was the
9 algorithm. All I did was the sum of the digits, if
10 you will, and because I wanted to preserve that
11 ranking one, two and three, one being the best and two
12 being second-best, I had to do the little numerator
13 thing up there so that number one would get the
14 heaviest rank. And so for an attribute that only has
15 three criteria in it, it splits out a 3.6, 2.6 and 1.6
16 for the weights, right?

17 MEMBER STETKAR: Is that for logic? Is
18 that for logic or --

19 MR. WATERMAN: Well, for four, it would be
20 .4, .3, .2. Four-tenths, three-tenths, two-tenths.
21 They all, four, three and two and one add up to ten,
22 right? Very simply. You know, in the absence of
23 having a lot of time to dig and determine some finer
24 scale of weighting, I thought well, this is probably
25 pretty good for me to be able to, you know, do a back-

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1 of-the-envelope judgment on various strategies.

2 MEMBER STETKAR: I think table A3 you
3 might have left a line off of.

4 MR. WATERMAN: A3.

5 MEMBER STETKAR: Table A3 is the basic
6 weight table. Continue. We don't have a lot of time.
7 Just check table A3.

8 MR. WATERMAN: A3?

9 MEMBER STETKAR: Yes.

10 MR. WATERMAN: Thanks, John.

11 On the diversity attribute weight
12 assumptions, the first assumption was that the
13 frequency of attribute usage is consistent with the
14 assumed or observed effectiveness of a diversity
15 attribute in addressing common-cause failures. In
16 other words, things that work people tend to use. And
17 so if a lot of people are using a particular
18 attribute, it looks like a lot of people decided, you
19 know, hey, that's a good attribute to use and so that
20 attribute should have a pretty good weight.

21 The second assumption on slide 34, design
22 constraints specific to a particular industry. The
23 use of a diversity attribute should be reflected in
24 the determination of the diversity attribute
25 effectiveness weight for that attribute. In other

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1 words, if there are industries out there that just
2 can't apply a particular attribute, well they ought to
3 be screened out before we determine a weight for the
4 diversity attribute usage. And that goes back to us
5 screening out aerospace and aviation, because that
6 domain there just isn't applicable to the nuclear
7 power industry, right? I mean, they have to keep the
8 plane flying, they can't shut down the engines, things
9 like that. And they really don't have a lot of room
10 for putting in diverse designs and diverse systems,
11 another rack and stuff like that. So, this assumption
12 here is the thing that helped us screen out things
13 that really aren't applicable to the nuclear industry.

14 MEMBER STETKAR: But another way to think
15 of that is that we do know the particular industries.

16 Those other design attributes ought to be assigned a
17 weight of zero when you look at the effectiveness of
18 diversity strategies for those industries.

19 MR. WATERMAN: Yes, for those industries.

20 But since I was only interested in the nuclear
21 industry --

22 MEMBER STETKAR: Fine.

23 MR. WATERMAN: Yes. The next assumption
24 was the decision to use a diversity attribute is
25 sufficiently independent of the decision to use other

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1 diversity attributes, which isn't totally true, right?

2 Because, for example, if you go with the design
3 diversity attribute, that's going to do an inherent
4 credit toward other types of diversity attribute
5 usage. I mean, if you're using analog to back up
6 digital, that automatically implies that your logic
7 attribute is going to be also affected, right?
8 Because the way the logic is instantiated. It may
9 also affect different manufacturers over in equipment
10 manufacturing attributes, but for doing frequency of
11 usage, I thought well, I'm willing to live with doing
12 that to come up with a relative effectiveness.

13 And the other thing about developing the
14 weights is that if you have an attribute where each of
15 the criteria within the attribute are mutually
16 exclusive, when you go out to look at frequency of
17 usage you should account for that type of things when
18 you're doing the weight calculation. So there were
19 three different ways of calculating diversity
20 attribute weights. The first way was for things that
21 are not mutually exclusive. You just sum up the usage
22 of; well, you can see it, the number of criteria. You
23 sum up the number of criteria in I used in attribute J
24 by the systems that are used to develop the weight.
25 And you sum up that number of usages and you divide by

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1 the number of system designs an agency position is
2 evaluated; that was that between-the-red-lines thing,
3 times the number of opportunities people had to use
4 all of those weights. For example, for the equipment
5 manufacturer, things have modified, because equipment
6 manufacturer is one of those mutually-exclusive
7 things.

8 For function, where you could use all of
9 the criteria within function for a particular design,
10 that value would be three up in here. So because
11 people could use one, two or three of those criterion
12 when selecting that attribute, which all we're
13 interested in is what do people think about using that
14 attribute. And so that's how I did the scoring on
15 that.

16 MEMBER BLEY: Can I just toss you an idea?

17 MR. WATERMAN: Sure.

18 MEMBER BLEY: On the surface this looks
19 pretty reasonable and, you know, the test will be how
20 well it works, but I just wanted to relate something
21 that I saw happen. And I don't fully understand -- I
22 haven't chased the arithmetic of why it happens. But
23 there's a human reliability method called SLIM that
24 was developed for NRC that in an odd sense is similar,
25 as John said, but it does weights and rankings for

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1 each characteristic, each performance shaping factor
2 and then your sum. Well, some people that I was
3 associated with, you know, were -- a couple of these
4 really, it shouldn't be a sum. It seemed to me they
5 ought to get multiplied together and then there ought
6 to be three more and then you ought to divide by
7 another one, because it just makes kind of sense. And
8 it did kind of look reasonable. What happened was
9 when you expanded it and did all that stuff, your
10 answers all complex to be almost exactly the same
11 thing. Didn't matter what you came in with, you
12 almost always get the same answer. So something weird
13 goes on in these kind of equations.

14 MR. GUARRO: Is the theorem of tendency to
15 the mean?

16 MEMBER BLEY: There's a central tendency
17 to --

18 MR. WATERMAN: Almost. But it's not
19 exactly right, but that's what's happening.

20 MR. GUARRO: That's it. I've seen it
21 happen.

22 MEMBER BLEY: But be a little careful,
23 especially if you start tweaking with these and trying
24 to things out, and do test them pretty thoroughly
25 on --

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1 MR. GUARRO: Which is why certain people
2 actually argue that when you assign weights, you
3 should use geometric progressions instead of try to
4 separate out more, if you really believe that there is
5 a different.

6 MEMBER BLEY: In fact that was the basis
7 for SLIM, although it hasn't always been used that
8 way.

9 MR. WATERMAN: What I found by using this
10 tool is the first time I input all the data I made
11 some mistakes and so I thought, ah, the weights are
12 wrong. So I went back and I fixed the mistakes that I
13 found that time and the weights changed a little bit.

14 But when I started looking at the average, that
15 number in that region, it really didn't change a lot.

16 The average moved up and down a little bit.

17 MEMBER BLEY: Maybe you're already there.

18 MR. WATERMAN: Yes. And I thought, well,
19 gee, you know, and so I went back in and scrubbed a
20 little bit more and found some other stuff. And the
21 weights have been changing; it's a work in progress.
22 The weights have been changing, but really everything
23 stayed kind of relative to -- you know, all the
24 strategies stayed pretty much relative to each other,
25 you know. Some were higher scores than others and it

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1 remained that way no matter how I changed those little
2 weights by making corrections to the data. And I
3 thought, geeze, does this mean that if I go get more
4 data, I'm really just, you know, marginal return on
5 the effort?

6 MEMBER BLEY: And like what you just said,
7 I think you need to make sure that in cases where
8 clearly you don't have enough diversity that you get
9 an index out of this thing that says so.

10 MR. WATERMAN: Yes. And this just talks
11 about design. There's also some equipment
12 manufacturer criterion in it. It was just a little
13 bit different way. On the mutually-exclusive, when I
14 looked at frequency of usage for that attribute, say
15 equipment manufacturer, if you look at those criteria,
16 it's really -- you can only select one of them. I
17 mean, you've got four options, but if you select one
18 you can't do the other, you know? Different
19 manufacturers of fundamentally different equipment, if
20 you say that's the way I'm going, you can't also say
21 they're same manufacturers of the same equipment.
22 Right? So they were mutually exclusive, so the number
23 of choices that you had for using criterion in that
24 was equal to one. And then that came out like that.
25 You notice at times N_C-something there, down on the

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1 bottom, is equal -- so that weight was calculated a
2 little bit differently. And if you look at the weight
3 per design especially, it's weighted 1.0 because in
4 the diversity approaches that we looked at to
5 determine the weights, one of the criterion design was
6 used by everyone of them. In other words, every one
7 of those examples, somebody decided we need design
8 diversity in here. We either need different
9 technologies or different approaches in the
10 fundamental technology or we just need different
11 architectures, AMD-versus-Intel-type thing.

12 And for logic processing equipment what we
13 found was that that was a mix of mutually-exclusive
14 and not mutually-exclusive. The first two criteria in
15 logic processing equipment or mutually-exclusive, but
16 the other two criteria could be used with either of
17 them. And so that came up with a little bit different
18 thing there. Instead of having four choices in logic
19 processing equipment, you'll really only have three if
20 you're going to design a system. You can pick one of
21 the first two and both of the second two, but you
22 can't pick both of the first two. They just exclude
23 each other. And so therefore you only a total of
24 three possible choices in one strategy.

25 And then we used those weights that we are

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1 starting out with to score all of the strategies to
2 come up with an average score, if you will. And that
3 was just the diversity criterion and times of
4 diversity attribute effectiveness weights for the
5 criterion attribute used in a particular design.

6 And then those things usually came out to
7 be some number and a fraction, like 2.38 or 1.96. And
8 me, I relate more to numbers in the hundreds that are
9 integers and so I just scaled it by hundreds so when I
10 looked at the scores I had, you know, a different
11 feel. But it's just linear scaling.

12 And then I averaged up the scores and then
13 use that average to normalize all the scores, because
14 it's always easier to compare something to 1.0, the
15 average, than it is to compare a number like 259 to
16 275. What does that mean? And so that's the general
17 algorithm that I used. And the spreadsheet does it,
18 so it's not really onerous. The spreadsheet just goes
19 through and adds up all these Xs and Is and comes up
20 with a score using the weights.

21 MEMBER BLEY: I see later in this you have
22 a reference to the tool, so if we go to that we'll get
23 the spreadsheet? Is that what that is?

24 MR. WATERMAN: Yes, I've got the
25 spreadsheet on here and I thought I would demonstrate

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1 it and put in some different views. It's kind of hard
2 to see on these screens because you have to scroll a
3 lot. Charlie and I, we worked through an example
4 yesterday and I'll show you how it works.

5 And then we normalize the scores with a
6 normalizing concept. Then this ought to look
7 familiar. This is 47, or 46 on yours, in which we
8 screened out aerospace and aviation applications. We
9 also screened out some various other applications that
10 just had minimal diversity usage, so it wasn't really
11 telling us how much diversity is enough. And then we
12 used the rest of these things in here to come up with
13 our weights.

14 MEMBER BLEY: Now once you get these
15 weights; I mean, you did all of these, the ones that
16 did come out low, how do you spin back to see why it's
17 coming out low?

18 MR. WATERMAN: Well, we went back and
19 actually looked at the design. We screened it out
20 originally because they just weren't using a lot of
21 diversity.

22 MEMBER BLEY: Okay.

23 MR. WATERMAN: I mean, they were just
24 backing up a system with a different function. It's
25 like that's it? You know, what about a technology

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1 approach? Aren't you worried about common-cause
2 failure in a microprocessors or an instrument, or
3 something like that? And they just weren't doing
4 that, you know? As a matter of fact, the report
5 documents which ones were screened out. I don't want
6 to call anybody and make them feel awkward here.

7 And then we had a couple of examples.
8 We've approved, as far as I know, I've been told we've
9 approved the Oconee low-pressure injection actuation
10 system, diverse low-pressure injection actuation. So
11 I don't know if that's gone out yet. So that's pre-
12 decisional, but anyway in talking to the branch chief,
13 he says yes, they found it acceptable. I don't know
14 what the status is on Oconee anymore. I'm not
15 involved in that. And so I scored it just to say oh,
16 really? Well, let's take a look at it. And actually
17 the first time I scored it they were still down at the
18 plant reviewing the system and Bill gave me a call and
19 said, "Hey, could you score this real quick for me and
20 see how it shakes out?"

21 MEMBER BLEY: So as you score one of
22 these, take one of those examples from another
23 industry that didn't score high, you kind of know as
24 you're scoring it that it's not good. The score just
25 gives you something to compare it to other things with

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1 and say I noticed it didn't have all of these and
2 look, here the scores comes out.

3 MR. WATERMAN: Yes, that's right, Dennis.

4 Thank you for bringing that up, because this is not a
5 draconian measure, thou shall reach the threshold or
6 else. This is more of a, look, their score is really
7 low. Maybe we ought to take a second look at this
8 when it comes in and really understand why the score
9 is so low. Maybe the score is so low and it's
10 appropriate. In that case there, well, it would still
11 be approved. But what it does do is if a licensee
12 addresses typical common-cause failure space that
13 we're all familiar with, their score is probably going
14 to end up in this red region. And that gives us some
15 comfort level, if you will, from the metric that, yes,
16 looking reasonable so far. That doesn't mean we're
17 going to just blindly rubber stamp it and say, well,
18 you made the score and you passed. But what it does
19 do is it tells us looks like we're all working on the
20 same track here. And so it reduces some of that
21 variability and judgment.

22 MEMBER BLEY: I just want to come back to
23 something you said earlier. If a design that --
24 essentially from everywhere on your wheel they'd get a
25 two, or something about a two.

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1 MR. WATERMAN: Yes.

2 MEMBER BLEY: So if it's higher than it's
3 not extreme. That's about it.

4 MR. WATERMAN: Yes, if they get that, but
5 that doesn't mean we don't review it.

6 MEMBER BLEY: Sure.

7 MR. WATERMAN: It just means it looks like
8 -- it gives us a comfort feeling, if you will, and it
9 gives the licensee a comfort feeling about their
10 certainty of getting approval that they don't have
11 right now. So that's why I've got this little arrow
12 out here that as the score goes up, the licensing
13 uncertainty will probably go up, too.

14 So now we're getting into the part that I
15 should have put up at the beginning of this, was the
16 implementation constraints. And the first is that
17 potential common-cause failure should be used
18 identified using operational experience, NUREG/CR-6303
19 and the BTP 7-19 analysis. All of those things go
20 into helping determine is there really a need for
21 diversity? So the first constraint is to determine
22 whether or not you have to address, you know,
23 diversity. And the second thing is when a design is
24 developed the design should identify, you know, should
25 address those identified common-cause failures.

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1 Somebody shouldn't just go willy-nilly into the table
2 picking up Xs to get a good score. And licensees, you
3 know, they've got a bottom line to worry about, so
4 they're going to design against common-cause failures
5 that they think are credible. But the design should
6 address each of the identified common-cause failures.

7 And on the flip side of that is all
8 credited diversity criteria should be in the design.
9 In other words, if somebody says these are the things
10 that give us the score, all of those things ought to
11 be in the design submitted for review and that the
12 staff should verify our actioning there. And I'll
13 show you how that creeps into here when we talk about
14 intentional selection of diversity criteria and the
15 inherent selection of diversity criteria as a result
16 of selecting certain criteria. And you'll see in the
17 demonstration about how things --

18 And the resulting diversity score should
19 fall within a yet-to-be-determined range of acceptable
20 scores. Now, we haven't determined that range yet. I
21 just through a shaded area on the plot there to give
22 you some concept. We're not looking for 1.0 or .95
23 anymore. We're looking for are you within a range of
24 acceptability. And part of that range is we go out
25 and we look at things that have happened in the past

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1 and what other people are common-cause failures and
2 determine, you know, these are the things that ought
3 to be addressed. Here's a research project right
4 there. These are things that ought to be addressed.
5 And so if they are addressed, scores should fall, you
6 know, above that limit, at that limit or above that
7 limit. So if we look at the things that ought to be
8 addressed, you should be able to calculate up a
9 diversity strategy to address that minimum set of
10 common-cause failures. That will give you the bottom
11 line and then we put in the pink area into that. And
12 that has to be worked out with industry. It has to be
13 worked out with the public, obviously, with you
14 gentlemen here and among the staff. We don't know
15 what that range is right now and it's just a
16 conceptual idea and we realize we've got a lot of
17 hammering to do on that one, too.

18 And then all the information that went
19 into justifying that strategy should be submitted to
20 the NRC so that we can plug it into our own metric,
21 right, and verify, yes, it's there. And so we can
22 start doing the reviews. When somebody says this is
23 how we're addressing design common-cause failure, we
24 can verify, yes, they did it. That's the way it is.

25 I suspect there's going to be some

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1 research on refining what those criteria mean. I
2 would hope we do more research, because just in
3 working with the staff in NRR they've come up with
4 some very interesting questions about what those
5 diversity criteria really mean. That's like, I didn't
6 think of that. So we probably need guidance to the
7 industry and to the staff about when somebody says
8 they're going to use different equipment manufacturers
9 for the same design, what does that mean? If one
10 vendor, for example, procures equipment for the
11 diverse system, is that a different manufacturer just
12 because the equipment is different, or is that the
13 same manufacturer? So we have to resolve those
14 things, too, we can give credit where credit is due.

15 And what's our path forward? Well,
16 obviously we want stakeholder feedback, and I'd just
17 look for as much feedback as I can. I realize that
18 some of the digits weighting is very subjective. It
19 looks quantitative, but it's subjectivity hidden
20 underneath quantification. But if somebody's got a
21 better idea for a better set of weights, you know, we
22 would really like to pursue that, if we can, and keep
23 refining this particular type of metric.

24 So what we've done is the evaluation tool
25 is available now publicly in ADAMS. I thought it was

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1 publicly all along. We put that into ADAMS, the first
2 version of that tool, back in December of last year.
3 A draft version of the NUREG, which you all have, is
4 also publicly available in ADAMS for the industry and
5 the public to review and provide comments on. And the
6 intention is to get those comments, weed through them
7 and incorporate all those good ideas into the NUREG to
8 make the NUREG that much more usable. And then
9 eventually as that NUREG gets polished off, we want to
10 incorporate that evaluation method into our licensing
11 process.

12 So, what I talked about today is that we
13 correlated experience and engineering judgment, if you
14 will, with the diversity attributes in NUREG and we
15 used that correlated data to develop a method for
16 evaluating diversity in I&C system design. And we
17 have a spreadsheet tool available in ADAMS. There's
18 that number again. And the draft is available for the
19 public and industry to comment on.

20 And the bottom line is that this licensing
21 uncertainty is just stifling the industry and it's
22 really tying up us in knots, too, over in regulation.

23 I'm just trying to address that issue. We are trying
24 to address it.

25 MR. HECHT: Mike, can I ask a question?

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1 MR. WATERMAN: Sure.

2 MR. HECHT: On slide 41 --

3 MR. WATERMAN: Oh, that's right. I'm one
4 slide ahead of you.

5 MR. HECHT: Oh, okay.

6 MR. WATERMAN: This one here?

7 MR. HECHT: No, I guess it would be slide
8 42.

9 MR. WATERMAN: How about that one right
10 there?

11 MR. HECHT: Yes. Right.

12 MR. WATERMAN: Okay.

13 MR. HECHT: I don't understand N_{C3}-1.

14 MR. WATERMAN: Okay. Okay. That was the
15 one where I was talking about in the logic processing
16 equipment, if you take a look at those diversity
17 criteria --

18 MR. HECHT: Yes.

19 MR. WATERMAN: -- criterion 1 and
20 criterion 2 are mutually exclusive.

21 MR. HECHT: I see.

22 MR. WATERMAN: You see? So whatever
23 diversity strategy you're using; I think it's
24 criterion 1 and criterion 2, whatever strategy people
25 use, they can only pick one or the other of those.

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1 MR. HECHT: Okay.

2 MR. WATERMAN: And so if I'm looking at
3 frequency of usage, I have to account for that when I
4 weight it out.

5 MR. HECHT: Right. Right. Okay.

6 CHAIRMAN APOSTOLAKIS: Any other comments
7 or questions from the members?

8 MR. HECHT: I do notice that you use the
9 word "score."

10 MR. WATERMAN: Score? Yes, I know. I
11 like metric better. I'm going to adopt that.

12 CHAIRMAN APOSTOLAKIS: The public has a
13 comment? Ted?

14 MR. QUINN: Sure. Yes. Ted Quinn,
15 representing Diablo today.

16 We're familiar with this report from last
17 summer and we honestly like it and we expect to use it
18 in our processes going forward. So there's two
19 comments to you.

20 One is related to software failures. I
21 think it's important to look at the old data and the
22 new data in relation to the importance of software
23 failures and their contribution to the potential for
24 CCF. And the old data is Bob Brill and Eric Lee that
25 came from years ago and it said that greater than 50

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1 percent of the errors were caused by -- in the
2 requirement space, or due to the thing. And you know
3 that from -- well, I think looking at the industry
4 data that they have, I just recommend it, that I think
5 you might see -- and you know, the old data was where
6 Nancy Levinson drew some of her conclusions. I think
7 the new data may change her conclusions and some of
8 the importance of where you may show it. It may give
9 you some benefit and robustness of your factors. I
10 think it's something to consider. Okay?

11 CHAIRMAN APOSTOLAKIS: You think it's not
12 50 percent anymore, Ted? Is that what you're saying?

13 MR. QUINN: I think; and I'll leave to the
14 experts who have done this hard work, I think it's
15 less. And that's number one.

16 Number two, I think it's important to ask
17 you to look at the DAS and the importance of the DAS.

18 And I'll just give an example. In General Electric,
19 I spent the last two-and-a-half years -- and were you
20 to this, Mike, up there today with the GE RPSS DAS,
21 which is, all four echelons are separated and there is
22 a full backup DAS, I think it would be a two on this
23 thing. Okay? It would be a number that is large.
24 But it has a full backup DAS. And the DAS has pluses
25 and minuses. And you know, the best lecture I know is

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1 Steve Hanauer on the benefits or the lack of benefits
2 of adding complexity to this. No mater what we do --
3 and I think your analysis is tremendous. What you're
4 doing is great work. Maybe it's a separate task to
5 look at DAS, I don't know. But I really think if you
6 could factor or look at where if the results of this
7 are X, then thing that I think George said awhile ago
8 was, well, what do you do with this? Where does this
9 number go in our D3 analysis, or explicit D3 analysis?

10 Well, part of it is the evaluation of a non-safety
11 DAS that I'm adding and the real benefits for it.

12 MR. WATERMAN: Thank you for bringing up
13 that point, Ted. The other area where you can use the
14 tool is actually when you're looking at your primary
15 system and determining do I have enough diversity in
16 the system that I don't need to worry about common-
17 cause failures and another system added onto it.

18 MR. QUINN: Agreed.

19 MR. WATERMAN: I think the GE system is
20 one, as I recall; it's been a while since I looked at
21 it, where they've got a ton of diversity with the
22 system itself.

23 MR. QUINN: They do.

24 MR. WATERMAN: Yes.

25 MR. QUINN: They do actually, between

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1 vendors and -- so your comparison of that would be
2 great, but again, number one is we're going to use
3 your work. Thank you.

4 MR. WATERMAN: And incidently, I did not
5 demonstrate the tool. So if you wish, I can do that.

6 CHAIRMAN APOSTOLAKIS: Demonstrate what?

7 MEMBER BLEY: The tool. Put in some
8 numbers, get an answer. Is that what --

9 MR. WATERMAN: What I did was, I've got
10 the tool here. I can't click to clear the worksheet.

11 There's a macro in the tool, so if anybody gets it
12 out of ADAMS, that macro allows you to clear all the
13 Xs and Os by clicking on that thing there. This
14 computer here has a security level too high, so I
15 can't run macros. So it's kind of a drag going
16 through and doing it manually. But in the case of
17 just talking about inherent credit and intentional
18 credit, intentionally selecting some criteria, like
19 different technologies, inherently credits other
20 criteria in there without the person actually
21 consciously going in and clicking those. For example,
22 let's just say we have a design that's using analog to
23 backup digital, which is easy. And by clicking an X
24 there, then inherently, because you have analog versus
25 digital, the architectures of those two systems are

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1 really going to be radically different. Right? I
2 mean, if you look at it here, you're going to have
3 relays strung together with wire versus software in a
4 digital.

5 John's over there. He's making me nervous
6 now.

7 There's an inherent credit that if you're
8 backing up a digital with an analog, you probably have
9 different manufacturers of those fundamentally
10 different designs. You've got one company who's
11 producing digital equipment, you've got another
12 company that's producing analog equipment. That's not
13 the case. Say you've got a company that can do it
14 all, you know, you could always put an N in there,
15 negate that. You could say it's the same
16 manufacturer, fundamentally different designs and you
17 could credit it like that. And these little weight
18 out in here, these are their criterion effectiveness
19 weights just transferred over to here and for the
20 boxes that aren't used, they stay zero so that I can
21 adding them up down in here in these subtotals.

22 MR. GUARRO: Mike, just one quick question
23 on that that I should have asked before, but I know
24 that your chart 30 said that, you know, you assumed
25 that you had to have different ways for the categories

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1 there, because what the NUREG-6303 did.

2 MR. WATERMAN: Yes.

3 MR. GUARRO: Have you looked at whether,
4 you know, that's still something you agree with, that
5 it was not allowing two factors to be equally
6 weighted? I mean, I don't know it's important. Just
7 as a conceptual point of view.

8 MR. WATERMAN: Yes, I went through and
9 read it real carefully, I just went out looking, how
10 can I weight this stuff? And so, I got into the
11 NUREG/CR-6303 and I noticed the relative
12 effectiveness. And so I went through there and sort
13 of verified for myself, yes, they're all different,
14 yes.

15 MR. GUARRO: Yes, because, I mean, you
16 know, from a conceptual point of view it seems that,
17 you know, depending on whether a certain major
18 category has more or less subcategories, it creates
19 more or less distance between your scores, which is
20 somewhat artificial in some cases.

21 MR. WATERMAN: Yes, it is.

22 Backing off there, just by selecting
23 intentionally different technologies we get a lot of
24 inherent credit for other types of diversity
25 attributes. For example, if you're going analog

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1 versus digital, way over in logic, you know, do you
2 have different languages? Yes, of course you do.
3 Because the way you described your analog system and
4 laid out the logic for that is totally different than
5 what you would do if you were writing a digital system
6 in C. So those are really different languages. Do
7 you have different algorithms? The actual algorithm
8 itself is going to be different, right, because of the
9 way the components are laid out. And so the tool
10 automatically credits things. Remember one of the
11 constraints is all of this credit that's given, the
12 licensee or the vendor and the staff have to ensure,
13 yes, those things do in fact exist in there. And the
14 one example I gave is if it's a different
15 manufacturer, well you don't get credit for different
16 manufacturers because it's the same manufacturer. But
17 you do get credit by checking an X in there and that
18 changes the score a little bit.

19 MEMBER BROWN: Just one comment on some of
20 the inherent ones. Dennis brought up the thought
21 process; I don't understand your orthogonal, I know
22 you're all orthogonal, non-orthogonal, whatever, but
23 once you select a different technology and then you go
24 down and you credit the different -- wherever it's --
25 down in the -- where it's a different language.

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1 MR. WATERMAN: Here we go. Yes.

2 MEMBER BROWN: And you say it's inherent.
3 You said one thing and I'm trying to pick up on
4 whichever one it was. Do you run the risk of adding
5 in some additional goodness that may -- you're
6 counting it twice, only maybe at a different level.
7 And when you hit one of those, it just happened to hit
8 me that, yes, maybe that might be one.

9 MR. WATERMAN: Yes.

10 MEMBER BROWN: For instance, in another
11 case where you give a differentiation at the top
12 between different architectures, which was .167, and
13 the different approaches within a technology, which is
14 .333. I think this is possibly a case where you could
15 assign equal weights almost, because there are some
16 fundamentally different architectures in the
17 microprocessor world that you can apply where you get
18 a benefit. Because all microprocessors themselves do
19 not have the same architecture. They're are inherent
20 differences included in their designs on the chips.
21 So you get different failure mechanisms. I just
22 wanted to try to provide an example based on the
23 discussion we had; that's all, since we've been
24 talking about it. I understand that, you know, you've
25 got to make some decisions about what to do. It's

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1 just it's not always real crisp that that applies,
2 that they're always less, none of them are equal, and
3 that you're not double counting somewhere. I think
4 some refinement in that thought process over and above
5 whatever you drive out of 6303 or 6033, whichever --
6 what is it, 6303 --

7 PARTICIPANTS: Sixty-three-oh-three, yes.

8 MEMBER BROWN: -- needs to be thought
9 about in terms of how you apply the thing.

10 MR. WATERMAN: Well, that double
11 accounting, it was more of a step back and really
12 thinking about that effects. You know, the whole
13 software thing is -- when it to be called software you
14 could say that's an analog system, no software, no
15 credit for different algorithms, no credit for any of
16 that stuff, and so your score comes out real low. And
17 I thought, you know, this reasonableness thing, is
18 that right? And so Richard had developed the whole
19 process of inherent and intentional selection, the
20 intentional drives some of the inherence. And so
21 while it appears to be double counting, for most of
22 that stuff you --

23 MEMBER BROWN: I'm not saying anything
24 new, Mike. I'm just saying that the issues are one.

25 MR. WATERMAN: The other issue on

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1 different -- I keep giving an example of Intel versus
2 AMD and, boy, if you look at an AMD microprocessor and
3 an Intel microprocessor, those are different animals.

4 You know, one's --

5 CHAIRMAN APOSTOLAKIS: I think you should
6 explore a different way of setting the weights, as I
7 suggested earlier, which address some of these
8 questions. But it's not really AHP itself. It just
9 occurred to me that the staff had a contractor, ISL,
10 develop a methodology for prioritizing the ITAACs.
11 And that's a fuller methodology than the AHP in the
12 sense that -- but it's very similar to what the
13 committee does in evaluating the quality of research
14 reports. It's exactly the same. It has relative
15 weights of attributes, but then within each attribute
16 you score how good it is, how well it is achieved. So
17 I have that report electronically. I can email it to
18 you, or you can dig it up. It was sponsored by the
19 Office of Research. But it is being used, I
20 understand, by the Atlanta office of NRO.

21 MR. CASE: I know of that report, so I can
22 get to it.

23 CHAIRMAN APOSTOLAKIS: Oh, wonderful.

24 MR. CASE: I'm Mike Case. I'm the
25 director of the Division of Engineering and Research.

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1 And so I know that --

2 CHAIRMAN APOSTOLAKIS: Oh, okay.

3 MR. CASE: -- about construction
4 inspection, so we'll get that to Mike.

5 CHAIRMAN APOSTOLAKIS: Yes. Very good.
6 But that might give you a different perspective.
7 Maybe if you ask the questions while you're looking at
8 it that Charlie and Dennis and others have asked,
9 maybe you can get some insights that would be useful.

10 Because the whole point of that approach is to
11 actually help you structure this kind of judgment.
12 Plus, then you can say we used this method which has a
13 name.

14 MR. WATERMAN: Well, the metric is
15 obviously the Apostolakis method.

16 CHAIRMAN APOSTOLAKIS: Hey.

17 MEMBER BLEY: You might run into some
18 trouble.

19 CHAIRMAN APOSTOLAKIS: And also, the ACRS,
20 you can look at the ACRS view. In fact, that's a much
21 simpler description of the methodologies, the ACRS
22 evaluation of the quality of research, which I believe
23 we're going to do for 6303, aren't we, Charlie?

24 MEMBER BROWN: Oh, is that one of them?

25 CHAIRMAN APOSTOLAKIS: Of this one.

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1 MR. WATERMAN: Oh, you're doing it on
2 this?

3 MEMBER BROWN: This one.

4 CHAIRMAN APOSTOLAKIS: Or do it on this?

5 MEMBER BROWN: This? Yes.

6 CHAIRMAN APOSTOLAKIS: But it's not the
7 finished product.

8 MR. WATERMAN: Yes. Well, I tried to
9 explain that.

10 MEMBER BROWN: That gives you ample
11 opportunity to make some astute and erudite
12 observations.

13 CHAIRMAN APOSTOLAKIS: We'll raise it next
14 week. I mean, we're supposed to review finished
15 products.

16 MEMBER BROWN: And this is not finished.

17 CHAIRMAN APOSTOLAKIS: No, this is not
18 finished.

19 MS. ANTONESCU: Well, Research offered it,
20 so --

21 CHAIRMAN APOSTOLAKIS: Well, the Research
22 made a mistake. Why? Because it's unfair to Richard
23 or to Mike. If we make a comment and then they say,
24 but we're thinking about it, then what do you do?
25 It's really unfair to review in that context work that

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1 is in progress. To have a Subcommittee meeting is
2 completely different, yes. No, I hadn't realized
3 that. I'm glad I haven't started.

4 MEMBER BLEY: Sixty-three-oh-three,
5 that's --

6 CHAIRMAN APOSTOLAKIS: Sixty-three-oh-
7 three is a NUREG. It's out. It's fair game.

8 MEMBER BROWN: One other point on the
9 assessment.

10 CHAIRMAN APOSTOLAKIS: Sure.

11 MEMBER BROWN: I mean, the weights, my
12 concern; and whether this is valid or not, I'm not
13 analytical enough to say, but the concern is you get
14 the wrong order. I mean, so you assign numbers to the
15 weights; a=-alf, .33, .167, if the order is correct
16 relatively, even though you may have slightly
17 different numerical assignments, you can kind of still
18 use it for relative judgments a little bit better. If
19 you get the order out of rank, if you get the order
20 out of order, okay --

21 CHAIRMAN APOSTOLAKIS: Wrong. If you get
22 it wrong?

23 MEMBER BROWN: You just get it wrong, yes,
24 and you're really compromising your ability to draw
25 conclusions from it. Again, it's just a thought that

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1 you're going through 6303 over to this and if those
2 guys thought about it and it was 15 years old and
3 therefore it's got to be right --

4 MEMBER BLEY: But they didn't think about
5 how much of it you need, kind of. They looked at each
6 thing.

7 MEMBER BROWN: Yes, although --

8 MEMBER BLEY: A is better than B, but this
9 one's doing a different thing.

10 MEMBER BROWN: Well, they ranked --

11 MEMBER BLEY: Out of A through Z, how many
12 do you need?

13 MEMBER BROWN: Yes, somebody determined
14 the order and they assigned a number.

15 CHAIRMAN APOSTOLAKIS: I think the order
16 is taken care of automatically in this hierarchical
17 approach, but I maybe misunderstanding what --

18 MEMBER BROWN: The order's been
19 predetermined based on 6303.

20 CHAIRMAN APOSTOLAKIS: Right.

21 MEMBER BROWN: And that's how old? When
22 was that written?

23 MR. WATERMAN: Fifteen years old.

24 MEMBER BROWN: Fifteen years old, and
25 things change.

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1 CHAIRMAN APOSTOLAKIS: If they go to this
2 new approach, I think that it will be a systematic --

3 MEMBER BROWN: What's AHP? Analytical
4 hierarchical process?

5 CHAIRMAN APOSTOLAKIS: Right. Yes, that's
6 what it is.

7 MEMBER BROWN: Okay. That's very
8 academic. I'm way down the --

9 CHAIRMAN APOSTOLAKIS: Which means it's
10 useless?

11 MEMBER BROWN: No. It just means I have
12 to learn about it, that's all. I suspect I'm going to
13 have to since it's in that study report.

14 CHAIRMAN APOSTOLAKIS: You guys in the
15 real world sometimes have to get out of our cocoon.

16 CHAIRMAN APOSTOLAKIS: Vice-versa.

17 CHAIRMAN APOSTOLAKIS: And go to the
18 unreal world --

19 MR. WOOD: Pay a visit to the ivory tower
20 every now and then.

21 CHAIRMAN APOSTOLAKIS: Mike, do you have
22 anything else to say that is of great interest?

23 MR. WATERMAN: No.

24 CHAIRMAN APOSTOLAKIS: Thank you very
25 much.

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1 I think there was a comment on this
2 presentation, right? If you're talking about your 10
3 minutes, that will come later.

4 We're done. Thank you very much.

5 Now, the public, NEI has requested some
6 time, so they will get 10 minutes or so. In fact, my
7 understanding is that it will be EPRI making the
8 presentation, correct?

9 But one important thing is as you know we
10 have postponed a presentation or two presentations
11 that were supposed to take place today. I suggest we
12 take 5-10 minutes to go get our calendars and decide
13 on dates here in session after Ray finishes his
14 remarks. Because we're talking about a June time
15 frame, maybe one week before, one week after, but
16 essentially that time. I think that's what Mr. Grobe
17 said yesterday, around June. Yes?

18 MR. ARNDT: I'd have to check collective
19 calendars, but the two obvious challenges for the
20 staff are the Commission meeting, which will probably
21 be the first week in June, the 2nd or 3rd of June, on
22 this same general area, I&C.

23 CHAIRMAN APOSTOLAKIS: So you want the
24 Subcommittee meeting to be before or after?

25 MR. ARNDT: I don't think it matters so

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1 long as it's not that same week. Preferably a week or
2 two after for our preparation time.

3 CHAIRMAN APOSTOLAKIS: Yes.

4 MR. ARNDT: And of course a number of the
5 Committee and probably some our prep people will be --

6 CHAIRMAN APOSTOLAKIS: Why we have to stop
7 the process and at least identify a couple of --

8 MR. ARNDT: Yes.

9 CHAIRMAN APOSTOLAKIS: Because, you know,
10 some of our calendars are pretty full, too.

11 MR. ARNDT: Correct.

12 CHAIRMAN APOSTOLAKIS: So why don't we do
13 that? Come back in about 10 minutes and bring
14 whatever information you can bring regarding your
15 commitments and then we'll give the floor to Mr.
16 Torok.

17 (Whereupon, at 11:04 a.m. off the record
18 until 11:14 a.m.)

19 CHAIRMAN APOSTOLAKIS: Okay. I think we
20 should start. Okay. Shall we resume? Okay. We're
21 back in session and we have a request for some time by
22 Mr. Ray Torok of the Electric Power Research
23 Institute.

24 So, Ray, you have about 10 minutes.

25 MR. TOROK: Okay. Thank you. Thank you

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1 for the opportunity. Yes, as you know, at one point
2 we were planning to give a presentation here today and
3 that didn't happen, but I wanted to follow up and talk
4 a little about, you know, what we would like to come
5 back and talk about and why we think it's a good idea
6 to do that. And, by the way, after listening for the
7 last couple of days, I am more convinced than ever
8 that it's a good idea for us to come back and talk
9 about these things some more, and I think I can
10 explain more why.

11 A couple of areas that we were going to
12 talk about have to do with the operating experience
13 evaluations that we did and you saw them referenced in
14 what Mike was talking about a few minute ago. And
15 also, PRA methods for digital, and, you know, that
16 came up several times yesterday. So those are
17 important topics. But also, there's another one
18 that's related to both really, which has to do with
19 failure modes, and failure mechanisms, and failure
20 effects for digital equipment. And it plays into both
21 really, because, you know, there's a question of what
22 we see in the operating experience that we looked at.
23 There's also the question of what does that mean
24 relative to PRA? So it's tied to both. So we want to
25 talk more about failure modes and mechanisms and that

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1 sort of thing.

2 CHAIRMAN APOSTOLAKIS: Well, as you
3 probably know, this Committee has been very interested
4 in failure modes.

5 MR. TOROK: I read your letter. That's
6 right.

7 CHAIRMAN APOSTOLAKIS: Well, somebody --

8 MR. TOROK: And we agree that it's a good
9 thing to keep --

10 CHAIRMAN APOSTOLAKIS: Very good. Very
11 good. Okay.

12 MR. TOROK: And I guess really in the area
13 of OE, we're talking about, in some sense, picking up
14 where we left off when we talked to this group back in
15 March and April last year, and where we were just
16 getting into this subject of failure modes and whatnot
17 when we ran out of time.

18 So we want to follow up with that
19 discussion and there are a number of things that we
20 can get into there. One of course is what we were
21 seeing in the data in terms of modes and mechanisms,
22 but also I think that leads us into more discussion of
23 specific events that we looked at and what the OE said
24 about it, and what the LER says about it, and how we
25 extracted our conclusions from that sort of thing.

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1 And I heard a lot of discussion in the last day around
2 that kind of issue, so I think that would be useful
3 and you guys will want to ask more questions about it.

4 Another thing that comes into play here is
5 the root cause analysis practices that utilities use,
6 and that's a very interesting exercise by itself. And
7 our guy, Bruce Geddes, our consultant here, has a fair
8 amount of experience in that and can enlighten us in
9 that area, and I think that's very useful.

10 Also, the notion of FMEA analysis as is
11 practiced today by vendors of the digital equipment,
12 you know, of the equipment going into the plants. I
13 think that's a real useful topic to get into more.

14 And with that, what I would characterize
15 as the realistic behaviors of digital systems,
16 especially systems being used for 1E applications.
17 There is this whole issue of realistic behaviors of
18 actual systems being used in the plants and being
19 proposed for the plants, because you know, there's a
20 difference between what's theoretically possible with
21 a digital system and what's possible in systems as
22 they're designed because of various design
23 characteristics that the vendors incorporate in them
24 and, you know, their impact on the actual failure
25 modes and effects and those kinds of things. And

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1 that's a very interesting discussion by itself.

2 And then finally, where does that leave
3 you in terms of modeling these things in PRA, you
4 know, in terms of failure mechanisms versus modes
5 versus effects and so on? And that brings me to the
6 PRA subject, right? In the area of PRA, a number of
7 questions have been raised here in previous meetings,
8 in letters and so on, in regard to the state of the
9 art of PRA and whether that's good enough for digital
10 equipment in terms of questions about level of detail
11 that you need for digital equipment is one, in terms
12 of possibly new failure modes and how those need to be
13 handled, in terms of establishing or estimating
14 failure probabilities. Right? These are all wide-
15 open questions.

16 But the fact of the matter is, the PRA
17 analyses are being done right now for new plants.
18 They're being done in some cases by operating plants.
19 They're being done by national labs on these systems.
20 They're being done by overseas utilities. So it's
21 happening. And the fact that it's ongoing now while
22 there are these big questions surrounding it means we
23 should be talking about it more. That's the way I
24 look at it.

25 Now, we sent you a report. We sent you

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1 two reports, right? One was our final OE report that
2 was published in December. The other was on an
3 example of applying PRA methods to a particular
4 digital issue.

5 MEMBER BROWN: Is that the risks and
6 benefits?

7 MR. TOROK: That's right. That's the PRA
8 one. And that describes how we applied PRA to a
9 particular issue to extract insights.

10 Now, in my mind what's important about
11 that report is not the specific conclusions of that
12 analysis. What's important is that it demonstrates I
13 think the usefulness of PRA in that we were able to
14 extract useful insights and the insights were
15 insensitive to the assumptions made in the analysis
16 and we did that without what I would call precise
17 knowledge of the failure modes or the probabilities of
18 failure. And that's interesting, I think. And to the
19 extent that you can do that with PRA, I think we
20 should be looking at it more and recognizing the
21 limitations of it, obviously. But it's a great
22 example, I think, of what you can extract right now.
23 So that's what we wanted to talk about.

24 Now, another thing was that, I guess
25 yesterday there was some question raised or a

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1 reference to industry continuing R&D, you know, on
2 digital issues, whether or not we are doing it or not
3 doing it. So I wanted to mention a few things that
4 are still ongoing.

5 In the area of common-cause failure in D3,
6 we are working this year on guidance on what we call
7 protecting against common-cause failure. Now I think
8 of that as sort of a more holistic broader version of
9 what Mike's got going on with his diversity deal.
10 Because the way we view it, the issue that you really
11 care about is not how diverse are you. The issue is
12 how good is your protection against common-cause
13 failure? And when you're protecting against common-
14 cause failure, diversity is not your only tool here.
15 Right? Because there are methods for prevention of
16 failures and there are also methods for mitigating
17 failures, and all of it should come into play. And
18 when you start talking about for digital system
19 failures in particular -- and by the way, we usually
20 don't say software common-cause failure, we say
21 digital common-cause failure, which is a little
22 broader and we'll explain that when we come back.
23 Okay? But the idea, I guess, is that you can talk
24 about design attributes and process attributes and so
25 on that are intended to prevent faults, for example,

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1 and others that are intended to prevent triggers. And
2 these are both useful in protecting against common-
3 cause failure. Now, if I talk about diversity, I'd
4 say, well, if I apply diversity within a system, then
5 I would call that a preventive measure because it
6 helps prevent common-cause failure. If I talk about
7 diversity between two different systems; for example,
8 in terms of a diverse actuation system, the so-called
9 DAS, that's a mitigated measure because it waits until
10 the primary system had its common-cause failure, then
11 it helps, then it backs it up. Right? So diversity
12 enters in both those contexts, I think. Right?

13 Now another thing that comes or is related
14 to that I think is of interest here, when we start
15 talking about design measures that can be useful in
16 protecting against common-cause failure, it's
17 interesting to see how that might flange up with what
18 Mike's doing. And I'll give you an example just so
19 you don't think I'm making this stuff up. One design
20 attribute of I guess a high-integrity digital system
21 would be that if there's a operating system, it's used
22 in the device in such a way that it's what we would
23 call blind-to-plant transients. Which means every
24 time step -- the operating system does certain stuff.
25 It looks at the inputs, it puts the inputs some place

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1 so the application code can pick them up and run with
2 them, it issues outputs, maybe it resets a watchdog
3 timer, those kinds of things. But every time step it
4 does exactly the same thing. So the operating system
5 can't tell what's going on in the plant; it doesn't
6 care. And that's a very interesting feature.

7 MEMBER BROWN: Hold it. But that's all
8 you're talking about is a main operating loop that
9 always does the same thing with every piece of data
10 every time.

11 MR. TOROK: Yes.

12 MEMBER BROWN: And nobody's dictating. It
13 makes absolute sense what you're saying.

14 MR. TOROK: But not every system does
15 that.

16 MEMBER BROWN: If you want a
17 deterministic system, then it has to do that.

18 MR. TOROK: And that's something --

19 MEMBER BROWN: And that's not addressed.
20 I mean, I've looked at three different systems and I
21 can't get anybody to define and show that they're
22 doing that. I keep asking about main operating loops
23 and that's the guy, oh, yes, they shake their heads up
24 and down, but there's nothing written in their
25 descriptions of their systems to do that. And all

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1 you've done is say that -- the way I read that is
2 somebody ought to be coming down and say, look, guys,
3 every digital -- and I'm using the broad term,
4 although it really applies in this case to software-
5 type systems for the --

6 MR. TOROK: Yes.

7 MEMBER BROWN: -- not combinational logic,
8 because that is pretty -- once you go, it flows.

9 MR. TOROK: Okay.

10 MEMBER BROWN: That it always does -- it
11 picks up every parameter, it executes every algorithm,
12 it goes through whatever partial test sequence in the
13 sample time that's left and it reiterates and it
14 finishes some sort of, you know, in-sequence testing
15 that you can do of the system while you're doing that.
16 And then it finishes and it strobos a watchdog, and
17 then it goes back and starts over again. It does
18 everything every time.

19 MR. TOROK: Right.

20 MEMBER BROWN: Now, that sounds good,
21 doesn't it?

22 MR. TOROK: Well --

23 MEMBER BROWN: Come on. I'm waiting for a
24 response.

25 MR. TOROK: Yes, it sounds good.

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1 MEMBER BROWN: Okay.

2 MR. TOROK: I'll go along with that.

3 MEMBER BROWN: But I don't see anything
4 that tells the vendors or the manufacturers or the
5 designers of these systems that that's what's
6 expected. I address that by talking about
7 determinacy, because that's the only way you can get
8 determinacy.

9 MR. TOROK: Okay. And I guess I would say
10 that's a characteristic that you would certainly want
11 to see in, you know, a 1E system in a nuclear plant,
12 right?

13 MEMBER BROWN: Yes.

14 MR. TOROK: Fine. And I would expect that
15 the plant, the licensees are making sure that their
16 vendors are doing that. Now, you're not going to read
17 about that in the brochures that come with the
18 equipment.

19 MEMBER BROWN: No, but --

20 MR. TOROK: You have to sit down with the
21 guys who design the box and look inside it and make
22 sure it's doing that.

23 MEMBER BROWN: You don't want a Bill Gates
24 operating system that does all kinds of things besides
25 -- oh, this time I'm going to do this, this cycle I'm

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1 not.

2 MR. TOROK: Right.

3 MEMBER BROWN: You know, and makes
4 executive decisions or evaluates the data. You just
5 want it to process.

6 MR. TOROK: That's right. And in
7 evaluating the systems you want to be pretty sure that
8 it's doing those things correctly, right?

9 MEMBER BROWN: Can we have you back? I
10 like this.

11 CHAIRMAN APOSTOLAKIS: We will have him
12 back, yes.

13 MR. TOROK: But we can go on all day on
14 this subject.

15 CHAIRMAN APOSTOLAKIS: No, no, no, no.
16 Are you approaching the end of your comments?

17 MR. TOROK: Yes. Yes.

18 CHAIRMAN APOSTOLAKIS: Okay.

19 MR. WATERMAN: Yes, this is Mike Waterman,
20 Office of Research. What you describe, Charlie, has
21 been a philosophy of the NRC's for as far back as I
22 can remember. For example, the Teleperm TXS system
23 does exactly what you described. I believe the Common
24 Queue does the same thing, too.

25 MEMBER BROWN: Well, I've been told MELTAC

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1 does also, but if you look at the DCD it doesn't say
2 that.

3 PARTICIPANT: It's not written down.

4 MEMBER BROWN: It's not written down
5 anywhere and how they accomplish that is not stated,
6 you know, because it has to literally be the main
7 operating loop, not a commercial-type non-real time
8 operating system.

9 MR. WATERMAN: And if you look at like the
10 safety evaluation or the Teleperm XS system that was
11 done in 2000, it goes into great detail about exactly
12 what you were describing. And we've been emphasizing
13 thou shalt be deterministic to the industry for, oh,
14 gosh, ever since I've been with the NRC. So those
15 particular features are in some of the major
16 platforms. I don't know about MELTAC.

17 CHAIRMAN APOSTOLAKIS: I think we had some
18 good --

19 MR. TOROK: I know Common Queue does it
20 and --

21 MEMBER BROWN: You just said everybody
22 doesn't do it. Now, I've only heard words.

23 CHAIRMAN APOSTOLAKIS: We've had some good
24 signs here that it will be an interesting meeting when
25 you come back, Ray.

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1 Now, you described a lot of stuff.
2 Roughly how much time will you need, do you think?

3 MR. TOROK: Well, I tell you, I sat here
4 and I've listened to, you know, the discussion of
5 Mike's topic and I think we're pushing four hours on
6 that. And when I add up all the stuff we have, it's
7 certainly more than four hours. So what I'd like to
8 ask for is a day on that, please.

9 CHAIRMAN APOSTOLAKIS: A day? The staff
10 will need how much time for their own presentations?

11 MR. ARNDT: It depends a little bit on
12 what you want to hear. There's a number of things
13 that we would like to present on. Certainly the
14 research plan, which I think the Committee is very
15 interested in hearing.

16 CHAIRMAN APOSTOLAKIS: The research plan
17 is absolutely important, yes.

18 MR. ARNDT: There's the final close-out of
19 the Brookhaven risk work that I believe Alan wants to
20 come back and talk about.

21 CHAIRMAN APOSTOLAKIS: Yes.

22 MR. ARNDT: I believe we wanted to talk
23 about ISG-07.

24 CHAIRMAN APOSTOLAKIS: So you're talking
25 about a day-and-a-half at least?

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1 MR. ARNDT: Probably. I'd have to go back
2 and add it all up. Probably in that ballpark.

3 CHAIRMAN APOSTOLAKIS: Well, then -- what?

4 MS. ANTONESCU: The I&C plan takes about a
5 day.

6 CHAIRMAN APOSTOLAKIS: The plan is one
7 day?

8 MS. ANTONESCU: Yes. Yes.

9 CHAIRMAN APOSTOLAKIS: Really? You're
10 planning a lot of things, huh?

11 MS. ANTONESCU: I don't know, it's up to
12 you.

13 CHAIRMAN APOSTOLAKIS: Well, the point is
14 this: The reason why I'm asking is because, first of
15 all, I think this is interesting work that Ray is
16 talking about. There is interest from the members.
17 Judging from past experience it's always good for the
18 Committee, Subcommittee and then the Committee to hear
19 from the industry because you have a different
20 perspective, especially in the old days of developing
21 the Regulatory Guide 1.174. It was very, very
22 valuable for us to hear the views of South Texas and
23 so on. So I think we should be generous and give as
24 much time as we can to the industry.

25 The bottom line is, is this becoming now a

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1 three-day meeting?

2 MS. ANTONESCU: Yes.

3 CHAIRMAN APOSTOLAKIS: Well, since we're
4 coming here, we might as well do something useful.

5 MS. ANTONESCU: Yes.

6 CHAIRMAN APOSTOLAKIS: What is the --

7 PARTICIPANT: Why now?

8 CHAIRMAN APOSTOLAKIS: -- point of coming,
9 you know, especially for you.

10 PARTICIPANT: Why now?

11 PARTICIPANT: Yes, for a change.

12 CHAIRMAN APOSTOLAKIS: For you guys to
13 come all the way from California, you know, might as
14 well get something out of you. That didn't come out
15 right.

16 I think, by the way, that we should be off
17 the record now. We are talking about planning the
18 meeting and the dates. There is no reason to have a
19 record, so unless Ray wants to add something.

20 MR. TOROK: The only other thing I was
21 going to say is we would like to do this in such a way
22 that we can support the detailed technical discussion
23 at whatever level you want to go. So we'd be bringing
24 our technical guys, which means people from California
25 and Atlanta and Paris. Okay?

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1 CHAIRMAN APOSTOLAKIS: And Paris?

2 MR. TOROK: Paris.

3 CHAIRMAN APOSTOLAKIS: Okay.

4 MR. TOROK: I'm sorry, we've got some
5 people in here from EDF who didn't get to speak today,
6 but he's got plenty to say later.

7 CHAIRMAN APOSTOLAKIS: Okay.

8 MEMBER BROWN: We should have at least
9 two-and-a-half days to let the guys get out --

10 CHAIRMAN APOSTOLAKIS: The official part
11 of the meeting is over. We're off the record now.

12 (Whereupon, the meeting was adjourned at
13 11:32 a.m.)

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United States Nuclear Regulatory Commission

Protecting People and the Environment

Digital I&C Licensing Process Task Working Group-6

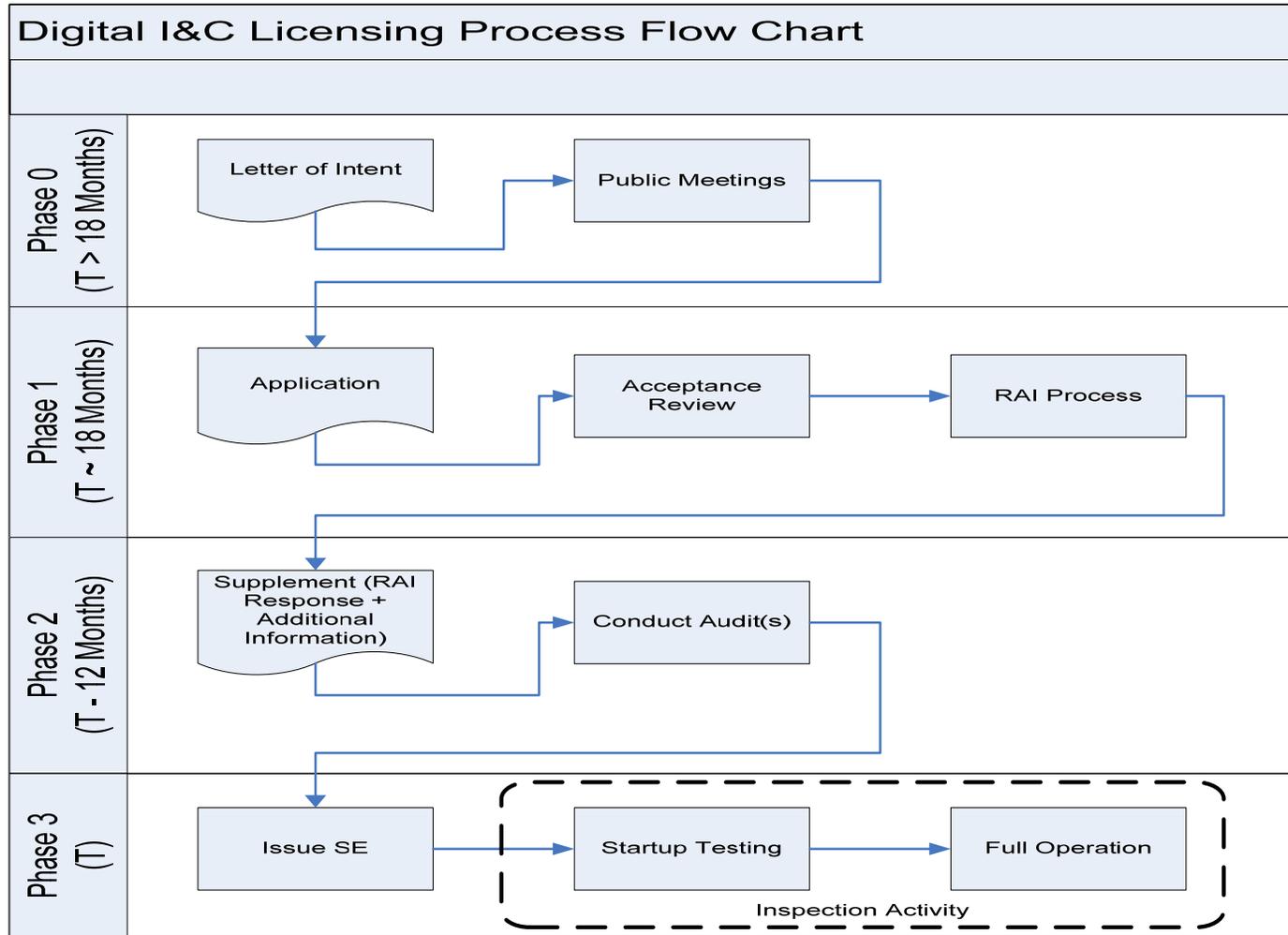
Lois James, Lead
Task Working Group 6
Office of Nuclear Reactor Regulation

February 26, 2009

- Introduction
- Process Overview
- Format of ISG-6
- Tiers of Complexity
- Phases of Process
- Areas of Review
- Path Forward
- Summary

- Purpose of ISG-6
 - Refined licensing process
 - Expectations for documentation
 - Knowledge management
- Lessons learned from recent I&C amendment reviews

Process Overview



- Introduction
- Purpose
- Licensing Process
 - Process Overview
 - Pre-Application Meetings
 - Initial Application
 - Continued Review and Audit
 - Implementation and Inspection
 - Review Areas
 - Scope of Review
 - Information to be Provided
 - Regulatory Evaluation
 - Technical Evaluation
 - Conclusion
- Appendices (Example Formats)

- Each Tier corresponds to an expected review complexity:
 - Tier 1: Previously approved system, no deviations from topical report, review to focus on plant specific aspects, least review effort expected.
 - Tier 2: Previously approved system, with deviations, moderate review effort expected.
 - Tier 3: Totally new system, extensive review effort expected. Thorough review of all technical areas.

- Encourage discussion of significant topics (defense-in-depth & diversity, variances from guidance, unique or complex aspects, etc.)
- Document meeting summaries
 - Can provide initial assessments and understanding of system concepts
 - Will document aspects that are important to the NRC staff decision
- Phase 0 ends with submittal of an LAR

- Staff will perform acceptance review in accordance with NRR Office Instruction, LIC-109
- Allowances are made for promised information
 - Appropriate to align staff review with system development lifecycle
- Staff can use RAI process to communicate those areas where the staff has no further questions
- Phase 1 ends when licensee submits all promised information
 - May overlap with Phase 2

- Staff will continue the in-depth review
- Staff will perform audit(s) of licensee design development process implementation
- Phase 2 ends with the conclusion of the NRC staff review

- Phase 3 begins with the issuance of the amendment and associated Safety Evaluation.
- Licensee implements upgrade
 - Installation of system
 - Amending of Technical Specifications
 - Procedure changes
 - UFSAR update
- Licensee will conduct startup testing
- Inspection of activities is governed by IP-52001, “Digital Instrumentation and Control Modification Inspection”

- The staff is developing a concise list of topical review areas to group the large number of criteria (IEEE Stds, GDC, BTPs, etc)
 - Review areas will be influenced by experience from current reviews
 - The list will also help knowledge management by allowing new reviewers to conceptualize the review process

- Monthly Public Meetings
 - Anticipate 1~4 Review Sections to be discussed
- Monthly conference calls on status

- Full Draft of ISG for Public Comment
 - Summer, 2009
- ISG-6 Issued
 - Fall, 2009
- Pilot application encouraged

- Tiers of review address differences in complexity
- Phases of review adapt licensing process to digital I&C system development lifecycle
- Review areas identify major aspects of a digital I&C review
- Path Forward



Digital Instrumentation Control Steering Committee Overview of Activities

John Grobe

Associate Director for Engineering and Safety Systems
Office of Nuclear Reactor Regulation

Stewart Bailey

Deputy Director for Digital Instrumentation and Control
Office of Nuclear Reactor Regulation

- Background on Steering Committee
- Digital I&C Project Products
- Other Key Digital I&C Issues
 - NRR Ongoing Reviews – ISG Usage
 - Operational Issues
- Path Forward

- Digital I&C Steering Committee formed January 2007
- 7 Task Working Groups formed to address specific issues
 - TWG-1 Cyber Security
 - TWG-2 Diversity and Defense in Depth (D3)
 - TWG-3 Risk-Informing Digital I&C
 - TWG-4 Highly-Integrated Control Room – Communications
 - TWG-5 Highly-Integrated Control Room – Human Factors
 - TWG-6 Licensing Process
 - TWG-7 Fuel Cycle Facilities
- Industry established counterpart groups
- Over 100 public meetings to define, discuss and resolve issues

- **Status of Activities**
 - Interim Staff Guidance (ISG) documents have been developed for technical issues related to power reactors
 - ISG is being developed for the licensing process
 - ISG is being developed for fuel cycle facilities
- **Ongoing Work**
 - Updates to Regulatory Documents

TWG-1: Cyber Security

- Problem: Perception of Conflicting Guidance between NEI 04-04 and RG 1.152
- Resolution: ISG-1 Issued 12/2007
 - No Conflicts Identified – Gaps/Different Scopes
 - ISG has Table Cross Referencing Requirements in RG 1.152 vs. NEI 04-04
- ACRS Review: Letter dated April 29, 2008
- Next Steps: Update SRP and RG 1.152 following Rulemaking and RG 5.71

TWG-2: Diversity and Defense-in-Depth (D3)

- Problem: SRM/SECY 93-087 Policy on D3. This TWG Provided Guidance on What Constitutes Sufficient D3 (6-part Problem Statement)
- Resolution: ISG-2 Issued 9/2007
 - Clarified when to Consider Common-Cause Failures (CCFs)
 - Guidance on Adequate D3, including Manual Action
 - Guidance on System vs. Component Level Actuation
- ACRS Review: Letter dated October 16, 2007
 - Recommends Process to Evaluate < 30 Minute Operator Action
- Next Steps: Complete NUREG on Diversity, Update SRP

TWG-3: Risk-Informing Digital I&C

- Problem: Need Guidance for (1) PRAs required by 10 CFR Part 52 for New Reactors, (2) How to use Risk Insights to Address Issues, and (3) State-of-the-Art PRA Methods
- Resolution: ISG-3 Issued 8/2008
 - Provided Guidance on New Reactor Applications
 - Defer Risk Insights and State-of-the Art PRA Methods
- ACRS Review: Letter dated April 29, 2008
 - Recommends emphasize failure modes vs. sensitivity studies
 - ISG-3 was revised to incorporate recommendations
- Next Steps: Risk Insights and State-of-the-Art to be Addressed in 5-year Research Plan

TWG-4: Highly-Integrated Control Room - Communications

- Problem: Guidance Needed on Separation, Inter-divisional Independence
- Resolution: ISG-4 Issued 9/2007
 - Guidance on inter-divisional communications (safety-to-safety or non-safety-to-safety)
 - Guidance on Command Prioritization
 - Guidance on Multidivisional Control and Display Stations
- ACRS Review: Letter dated October 16, 2007
- Next Steps: Update SRP, RG 1.152, and IEEE 7.4.3.2

TWG-5: Highly-Integrated Control Room – Human Factors

- Problem: Guidance Needed on (1) Minimum Inventory, (2) Computerized Procedures, (3) SPDS, (4) Graded Approach to Human Factors, (5) Manual Action for D3
- Resolution:
 - (1) and (2) ISG-5 Issued 9/2007
 - (3) Requires Rulemaking
 - (4) Dropped
 - (5) ISG-5 Issued 11/2008
- ACRS Review: Letter dated October 16, 2007
 - Present ISG on Manual Action today
- Next Steps: Rulemaking, NUREG, Reg. Guide, SRP

TWG-6: Licensing Process

- Problem: Need Guidance on (1) Level of Detail in Submittal, (2) Applicability of SRP Chapter 7, (3) Process Protocols, and (4) Licensing Criteria for Cyber Security
- Resolution: ISG-6 Under Development
 - Inspection Procedure Issued 10/2008
 - Audit Procedure Issued 12/2008
- ACRS Review: Letter Dated April 29, 2008
 - Present update today
- Next Steps: Complete ISG, Add Cyber Security, Final Documents

TWG-7: Fuel Cycle Facilities

- Problem: Need Guidance on (1) Cyber Security, (2) Diversity, (3) Independence of Control Systems, (4) Isolation, and (5) High-quality Software
- Resolution: ISG-7 Under Development
- ACRS Review: Request Review End of Summer
- Next Steps: Complete ISG, Update NUREG-1520, new NUREG

- Wolf Creek

- Field Programmable Gate Array (FPGA) use for Main Steam and Feedwater Isolation System
- Staff using ISG-2 and ISG-4
- Staff Conducted Audits at Vendor Facilities
- Draft Safety Evaluation is in Peer Review, Completion by April 2009

- Oconee

- Microprocessor-based Teleperm XS (AREVA) use for Reactor Protection and Engineered Safety System (combined), Submitted 1/31/08.
- Staff Acceptance Review/Letter Identified Six Issues to Resolve
- Staff using ISG-2 and ISG-4
- Staff Conducted Audits at Licensee and Vendor Facilities
- The Review is Progressing, and Pathways to Resolve Issues have been Identified

- Issues Identified to Date
 - Provisions for hardware/software changes (10CFR50.59)
 - Dealing with the evolution of previously-approved platforms in licensing
 - Assessing findings using the Significance Determination Process
 - Handling risk-informed licensing issues
 - Risk-informed technical specifications initiatives
 - Previously-approved risk-informed submittals
 - Allowed outage time extensions
 - Implementing the maintenance rule (10CFR50.65(a)(4))
 - Monitoring shutdown risk
 - Evaluating the safety significance in Licensee Event Reports (10CFR50.73)
- Plans for Resolution

- Complete ISG for Licensing and Fuel Cycle Facilities
- Update Regulatory Documents
- Address Operational Issues
- International Cooperation
 - MDEP - Bilateral Work
 - COMPSIS - IAEA and Other Interactions
- Ongoing Research Activities



Digital I&C Highly Integrated Control Room Human Factors Task Working Group #5

Interim Staff Guidance for Crediting Manual Operator Actions in Diversity and Defense-in-Depth Analyses

David R. Desaulniers
Office of New Reactors

February 26, 2009

- Overview of TWG-5 and activities
- Manual Operator Action Background
 - DI&C-ISG-02
 - Industry white paper
 - Challenges
- Overview of ISG for crediting manual operator actions
- Path Forward

Task Working Group

- Michael Junge, NRO (Manager)
- George Lapinsky, NRR*
- Larry Vick, NRR*
- J. Persensky, RES*
- David Desaulniers, NRO*
- James Bongarra, NRO
- Barry Marcus, NRR
- Jack Zhao, NRO
- Jonah Pezeshki, NRR
- Paul Pieringer, NRO

*Principal contributor to ISG for manual operator action

Areas of Expertise

- Human Factors
- Instrumentation and Controls
- Plant Operations
- Operator Licensing
- Plant Simulation

Key areas

- Minimum Inventory
- Safety parameter display system
- Computer-based procedures
- Graded approach to human factors
- Manual operator actions

DI&C-ISG-05 Topics

- Computer-based procedures
- Minimum inventory
- Manual operator actions

DI&C-ISG-02, Interim Staff Guidance on Diversity and Defense-in-Depth Issues, September 26, 2007

- Provided acceptable methods for implementing diversity and defense-in-depth (D3) in digital I&C system designs
- Clarified use of operator action as a diverse defensive measure and established corresponding operator action times

DI&C-ISG-02:

- The D3 analysis may determine that one or more reactor protection system (RPS) safety functions could become subject to a common cause failure (CCF)
 - use realistic assumptions to perform analyses of licensing basis plant responses
 - identify back-up systems or actions necessary for accomplishing the required safety functions

DI&C-ISG-02 states:

“Manual operator actions may be credited for responding to events in which the protective action subject to a CCF is not required for at least the first 30 minutes and the plant response is bounded by BTP 7-19 recommended acceptance criteria.”

DI&C-ISG-02 further states:

“The licensee or applicant should demonstrate through a suitable human factors engineering (HFE) analysis that manual operator actions that can be performed inside the control room are acceptable in lieu of automated backup functions.”

- Industry sought flexibility and guidance to credit manual operator actions in less than 30 minutes
- Scope of TWG-5 action plan expanded to develop guidance for crediting manual operator actions
- Public interactions between TWG-5 and industry counterparts
- Industry developed white paper methodology for crediting manual operator actions
- Staff considered and incorporated, as appropriate, white paper methods in developing an amendment to DI&C-ISG-05

Summary of Industry-proposed Methodology

- Analysis
 - Time required for operator action calculated using a modified ANSI/ANS 58.8, 1994 methodology
 - Time available calculated using T-H models
- Verification
 - Operator action times confirmed through table top exercises
- Validation
 - Conducted using part-task, limited-scope, or plant reference simulator and captured as an ITAAC or license condition
- Human Performance Monitoring
 - On-going operator training

ANSI/ANS 58.8, Time Response Design Criteria for Safety-Related Operator Actions, 1994

- Provides a methodology for analyzing an action sequence and decomposing the task into discrete time intervals
 - e.g., diagnosis, response selection, manipulation
- Developed as a means to establish the minimum allowable response times for operator actions in response to design basis events
 - Uses specified time values for task intervals that are aggregated to calculate total response time
- Method has not been endorsed by NRC

Technical Issues/Challenges

- Analysis
 - Use of modified ANSI/ANS 58.8 methodology
 - Use of unique prompting alarms to significantly reduce time allotted for diagnosis
- Verification
 - Lack of specificity regarding purpose, scope & implementation
- Validation
 - Adequacy of simulation
 - Fidelity of facility
 - Number/scope of scenarios
 - Crew size
- Human Performance Monitoring
 - Lack of specificity regarding scope & implementation

Key Issues

- Focus on feasibility with little emphasis on reliability of operator actions
- Process weighted toward integrated system validation activities which occur late in the licensing process

Manual Operator Action ISG

- Scope
- Staff Position
- 4-Phase Methodology

Scope

- Manual actions credited in D3 analyses for coping with abnormal operational occurrences and postulated accidents (AOO/PAs) concurrent with software CCF of the digital protection system
- New and existing reactors

Staff Position

Credited actions should be:

- Included in emergency operating procedures (EOPs)
- Executed from within the main control room
- Demonstrated to be feasible and reliable
- Addressed in the human factors engineering (HFE) program consistent with NUREG-0711

Method

4-Phases:

- Analysis
- Preliminary Validation
- Integrated System Validation
- Long-term Monitoring

Analysis

Objective

- Estimate *time available* and *time required*
- Identify critical assumptions and credible operator errors
- Establish adequate *margin*

Analysis

Method

Time Available

- Use methods and realistic assumptions consistent with BTP 7-19.

Time Required

- Use a documented sequence of actions (from task analysis, EPGs, EOPs)
- Use one of several acceptable methods for developing estimates of time required to perform action sequence

Margin

- Time to recover from credible errors

Analysis

Examples of Acceptable Methods

- Operator interviews and surveys
- Operating experience reviews
- Software models of human behavior, such as task network modeling
- Use of control/display mockups
- Expert panel elicitation
- ANSI/ANS 58.8, *Time Response Design Criteria for Safety-Related Operator Actions (task decomposition)*

Analysis

Review Criteria Topics

- Time required
- Time available
- Use of alarms, controls, and displays
- Use of symptom/function-based EOPs
- Staff size, composition and augmentation
- Level of detail
- Identification of credible operator errors

Analysis

Example Criteria

- The estimated time response of operators is sufficient to allow successful execution of applicable steps in the symptom/function-based EOPs
- The initial MCR operating staff size and composition assumed for the analysis of time required is the same as the minimum MCR staff defined in the unit's Technical Specifications

Preliminary Validation

Objective

- Independent confirmation of analysis results

Applicability

- Only required for those vendors/applicants who are using the 10 CFR Part 52 process

Method

- Use diverse methods that are as realistic as maturity of design allows
- Submit analysis and results for NRC review as part of D3 submittal(s)

Preliminary Validation

Examples of Acceptable Methods

- Tabletop analysis
- Walkthrough/talkthrough analysis
- Software models of human behavior, such as task network modeling
- Use of control/display mockups
- Man-in-the-loop prototype testing
- Real-time validation using part-task simulator

Preliminary Validation

Review Criteria Topics

- Independence from Phase 1
- Validation team qualifications
- Use of two or more methods
- Validation of time required

Preliminary Validation

Results

- Shall be documented in the D3 analysis for NRC review
- Should support high confidence that the time required for manual operator actions will satisfy the success criteria for the integrated system validation

Preliminary Validation

Unacceptable results

- Should result in modification of the D3 coping strategy

Acceptable results

- Provide basis for a safety determination conditioned upon the completion of any HFE open items, ITAAC, COL open items

Integrated System Validation

Objective

- Confirm operators are able to perform credited actions in real-time using as-built design

Method

- Use plant-referenced simulator capable of realistically representing AOO/PA with CCF
- Validate time required using both nominal and TS minimum crews
- Accomplish as part of HFE program activities per NUREG-0711

Integrated System Validation

Plants licensed under 10 CFR Part 52

- Implement and document as an ITAAC item or COL action item

Operating plants

- Review as part of license amendment

Integrated System Validation

Review Criteria Topics

- Integration with HFE program
- Simulator
- Personnel
- Operational Conditions
- Performance Times

Integrated System Validation

Performance Time Criteria

- For each AOO/PA, the *mean performance times* of the crews is less than or equal to the estimated *time required* derived from the analysis phase.
- For each AOO/PA, the *performance time* for each crew, *including margin* determined in the time required analysis, is less than the analyzed *time available*.

Integrated System Validation

Unacceptable results

- Should result in modification of the D3 coping strategy

Acceptable results

- Provide the basis for meeting the license application or amendment request approval requirements
- Shall be submitted for final NRC review and closure of any HFE open items, ITAAC, COL action items, or License Conditions

Long-term Monitoring

Objective

- Ensure credited actions remain feasible and reliable

Method

- Design and configuration controls ensure discrepancies from D3 assumptions and constraints are identified and corrected
- Training keeps performance within assumptions of the analysis

Long-term Monitoring

Review Criteria

- A long-term monitoring strategy is capable of tracking performance of the manual operator actions to demonstrate that performance continues to support the associated D3 analysis
- The program is structured such that corrective actions are formal, effective, and timely

- Develop draft Regulatory Guide
- Support future development and revision of ANSI/ANS 58.8, Time Response Design Criteria for Safety-Related Operator Actions