American Nuclear Society

Risk-Informed and Performance-Based Principles Policy Committee (RP3C)
Octavius 22, Caesars Palace, Las Vegas, NV
November 7, 2016

Members Present:
N. Prasad Kadambi, RP3C Chair, Individual
Edward Wallace, Vice-Chair, GNBC Associates, Inc.
*James August, Southern Company
Robert Budnitz, Lawrence Berkeley National Laboratory
Donald Eggett, Individual
George Flanagan, Oak Ridge National Laboratory
Alan Levin, U.S. Department of Energy
Mark Linn, Oak Ridge National Laboratory
Carl Mazzola, Chicago Bridge & Iron Federal Services
James O'Brien, U.S. Department of Energy
*William Reckley, U.S. Nuclear Regulatory Commission
William Reuland, Individual
Andrew Smetana, Savannah River National Laboratory
Robert Youngblood, Idaho National Laboratory

Guests:
David Johnson, ABS Consulting
Don Spellman, Individual
*Steven Stamm, Individual
Dominic Winstanley, Sellafield Ltd, UK

*participated by phone

Members Absent:
Amir Afzali, Southern Company
Wayne Andrews Jr., Individual
Edward Blandford, University of New Mexico
Richard Browder, Duke Energy
Robert Eble, AREVA Inc.
Kamal El Sheikh, The Cameron Group, Inc.
Yan Gao, Westinghouse Electric Company, LLC.
Gerry Kindred, Tennessee Valley Authority
Stanley Levinson, Individual.
Thomas Marenchin, U.S. Nuclear Regulatory Commission
Ronald Markovich, Contingency Management Consulting

1. **Welcome &Introductions**
   RP3C Chair Prasad Kadambi welcomed all to the meeting. Introductions were made.

2. **Approval of Meeting Agenda**
   Prasad Kadambi reviewed the items planned for discussion at the meeting. The agenda was approved with the addition of a presentation from Ed Wallace on behalf of Amir Afzali on a Southern Company project to be shared during lunch for those interested.

3. **Approval of June 13, 2016, Meeting Minutes**

   Prasad Kadambi reviewed salient points of discussions from the June 13, 2016 meeting. He reminded members that the concept of the Standards Application Platform (SAP) was presented at the last meeting. He explained that the SAP provides risk-informed and performance-based (RIPB), integrated decision making. Members also discussed the SAP with respect to ANS-30.1 "Integration of Risk-Informed, Performance-Based Principles and Methods into Nuclear Safety Design for Nuclear Power Plants," and consideration of ANS-30.2 "Categorization and Classification of Structures, Systems, and Components for New Nuclear Power Plants." Kadambi added that the last meeting covered Robert Youngblood's proposal on Design Basis (DB) and Beyond Design Basis (BDB) Events and a Performance-Based (PB) Framework (safety cases and GSI-191). Kadambi suggested a design guidance standard with scenario-based, design decisions to support licensing bases.

   Kadambi directed members to Slide 4 of his presentation (Attachment 1--Meeting Presentation) with a diagram of a RIPB SAP for the Research and Advanced Reactors Consensus Committee (RARCC). He described the format of the SAP for RARCC explaining that it showed the relationship and dependencies of the projects within the consensus committee. Working groups would identify relevant documents and populate the SAP for new standards. The SAP for revisions of existing standards would be populated by the consensus committee. There could be a combination of alternatives to capture the SAP. George Flanagan expressed concern that creating a SAP was additional work that could detract from developing a standard and extend the length of the development process. Kadambi sees the SAP as a resource that would be available for new members to bring them up to speed. Robert Budnitz questioned whether the SAP was an archive. If that's what it is, he sees value in this for future working groups. Kadambi explained that the SAP included an archive, but it was more than that as it captures hierarchy and relationship. Steve Stamm said that the diagram is not a plan but a proposal and questioned whether it fulfilled the RIPB Plan. Kadambi felt you needed the SAP if you want to do RIPB work. Mark Linn proposed that Ed Wallace provide him the detail so he may create a SAP and work with his group to populate and use as a pilot.

   > Action Item 11/2016-01: Ed Wallace to provide Mark Linn specifics on the SAP so that his working group can populate a SAP for ANS-30.1.
   > DUE DATE: N/A[1]

   > Action Item 11/2016-02: Mark Linn and the ANS-30.1 Working Group to develop a SAP.
   > DUE DATE: N/A[1]

   Kadambi summarized the use of a safety case for Beyond Design Basis Events (BDBEs) (Attachment 1, Slide 7). Robert Youngblood addressed the RP3C. He explained that the overarching need is to identify the difference between DB and BDB which requires thought. Youngblood feels a practical way is through a safety case.

   Kadambi suggested that the committee define performance based. He defined it himself as "doing the right things and observing results on the way to achieving desired outcomes."

   Youngblood explained Slide 8 and the change of color to reflect a move from very low frequency to low frequency. Slide 9 provides criteria for validating simulation models from "practical" to validate to "harder" to validate. A safety case using GI-191 was used as an illustration.

   Kadambi reminded members that he suggested a guidance design standard could be developed. It is his sentiment that a guidance design standard would be useful for design decisions for advance reactors.

   The minutes of the June 13, 2016, meeting were approved as presented.

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[1] This action item was superseded by a decision of the Standards Board to develop documentation requirements for all ANS standards committees.

4. **Modernization of Technical Requirements for Licensing of Non-Light Water Reactors**

Ed Wallace explained that he would be making a presentation on modernization of technical requirements for licensing of nonlight water reactors on behalf of Amir Afzali. Both Wallace and Prasad Kadambi are among a number of individuals supporting Afzali with Southern Company on this project. His presentation is available as Attachment 2 for more detail. Wallace stated that the proposals will come out as white papers. He expects that a need for a number of standards will be identified some of which will be within ANS's charter. Wallace emphasized the need for this effort to be expeditious to avoid future problems. He confirmed that conversations were taking place with international experts and that this association will be formalized. Wallace clarified that team members are a cross-section of the industry led by utilities. He stated that the list of participants is on the NRC's website for the October 25, 2016, meeting. Wallace will provide the list of participants to be included with the minutes (Meeting summary with attendance list and slides available in ADAMS here.)

> Action Item 11/2016-03: Wallace to provide the list of participants in the Southern Company project on the modernization of technical requirements for licensing on nonlight water reactors.
> DUE DATE: June 1, 2017

Wallace summarized the Project Deliverables Master Logic Flowchart, Slide 5 of his presentation, to explain their process. The group will disband in two years when completed. Wallace stated that it is an aggressive schedule that needs support from many to be successful. The dates for completing the white papers are provided in Slide 6. The references will be available for use in the RP3C SAP.

5. **Review of RP3C's Roles and Responsibilities**

Identifying and Addressing Gaps between RP3C Charter and Evolving Role
Prasad Kadambi read the RP3C's charter (see Slide 12 of Attachment 1). He stated that it is essential that we take a strategic view of how to go forward for a PB framework. He believes there is enough leverage between the National Technology Transfer and Advancement Act and Office of Management and Budget Circular No. A-119. Kadambi stated that the outcome from the project with Southern Company is a technology-inclusive, risk-informed, performance-based design and licensing framework for nonlight water reactors. Kadambi believes that RP3C can help shape the outcome by contributing views based on informed deliberations on a number of questions. Members discussed the use of the American National Standards Institute Project Initiation Notification System (PINS) form or possibly a project plan to address these questions and the role of RP3C. Ed Wallace sees this as a conversation for the Standards Board. James O'Brien suggested that a plan be prepared on how all of this works together. Robert Budnitz confirmed that the Joint Committee on Nuclear Risk Management (JCNRM) does not have any guidance documents they use for writing probabilistic risk assessment standards. He added that the JCNRM has a subcommittee on risk application that helps other committees develop risk-informed standards.

Kadambi reminded members that a suggestion to develop a process standard was proposed that will need to be considered by the Standards Board. The RP3C Bylaws would need to be revised to address this.

> Action Item 11/2016-04: Prasad Kadambi to check with the Standards Board to see if the RP3C Bylaws should be expanded to permit the development of a process standard.
> DUE DATE: June 1, 2017

> Action Item 11/2016-05: Prasad Kadambi to check with the Standards Board to see if RP3C is allowed to address the questions coming out of the licensing-modernization project.
> DUE DATE: June 1, 2017

Wallace reiterated that some of the white papers from the licensing-modernization project should be available next June (2017). RP3C and consensus committee members will have the opportunity to review if interested.

Members discussed how RP3C can provide support to working groups in risk-informing standards in the initial stage as they are forming the working group and developing a PINS. Flanagan suggested that the RP3C needs to provide something concrete to include in the consensus committee procedures on how RP3C should interface with working groups. Carl Mazzola added that we don't want the way committees work with RP3C to be ad hoc.

6. **Status of Interaction with WGs**

- Interaction on draft ANS-2.8 "Probabilistic Evaluation of External Flood Hazards for Nuclear Facilities" [revision of withdrawn standard ANSI/ANS-2.8-1992 (W2002)]
  A group within RP3C was formed to review ANS-2.8. While they found it acceptable, they found that the draft standard does not include performance-based methods. Because the draft already had been completed and was at the consensus committee ballot level, the chair feels that performance-based methods should be added in the next revision. The working group will need to define what the user wants to accomplish.
- Interaction on ANS-30.1, "Integration of Risk-Informed, Performance-Based Principles and Methods into Nuclear Safety Design for Nuclear Power Plants" (new standard)
  Mark Linn explained that the working group was finding it difficult to adopt high-level concepts into the standard. He would like RP3C to review the current draft and provide the objectives for each section to make sure they are addressing the objectives appropriately. Prasad Kadambi felt that it was the role of the working group to set the objectives. Kadambi clarified that when he talks about objectives, he is talking about the user's needs – the outcome of the application of the standard.

Linn gave an example of the requirements analysis process and questioned what the objective should be. Wallace asked that Linn provide him a copy of the current draft to review. Flanagan asked Linn to provide an explanation of what feedback he is looking for.

Action Item 11/2016-06: Mark Linn to provide the current draft of ANS-30.1 to Pat Schroeder along with an explanation of the feedback he needs.
DUE DATE: December 1, 2016

Action Item 11/2016-07: Pat Schroeder to issue the ANS-30.1 draft to RP3C for comment.
DUE DATE: December 1, 2016

Action Item 11/2016-08: RP3C to provide feedback to Mark Linn on the ANS-30.1 draft.
DUE DATE: January 15, 2017

- Interaction on draft revision to ANS-51.10 "Auxiliary Feedwater System for Pressurized Water Reactors" [revision of ANSI/ANS-51.10-1991 (R2008)]
  Several RP3C members reviewed the draft of ANS-51.10 and found that it did not include risk-informed methods. The effort to risk-inform the standard was considered to be a significant effort. With the draft developed and the loss of active working group members, the chair prefers to wait until the next revision to incorporate risk-informed methods.

7. **Standardization of Performance-Based Consideration of Licensing Basis Regions**
   Prasad Kadambi used slide 23 of the meeting presentation (Attachment 1) to explain a PB Framework. George Flanagan suggested that the slide be summarized for members. Ed Wallace informed members that a white paper was in developed to answer this question. The white paper is due by April 1, 2017. Flanagan asked for a simple one-pager be prepared to summarize a PB Framework for consensus committee chairs to review.

Action Item 11/2016-09: RP3C/Prasad Kadambi to prepare a one-pager to summarize a PB Framework.
DUE DATE: April 1, 2017

Action Item 11/2016-10: Consensus committee chairs to review the PB Framework white paper once developed.
DUE DATE: May 1, 2017

Kadambi explained scenario-based, performance-based requirements (Slide 27) and used the PB Framework based on NUREG/BR-0303 (Slide 28) as an example. George Flanagan stated that another outcome that is needed is what you gain through performance-driven processes. Kadambi explained that flexibility is key to the performance-based approach. James O'Brien added that an example of a standard that uses performance-based methods well would be helpful. Flanagan suggested that a brief, five-slide presentation be prepared providing a simple perspective of what risk-informed/performance-based is about that can be provided at each consensus committee meeting. Members agreed this would be beneficial.

Action Item 11/2016-11: RP3C to prepare a brief, five-slide presentation with a simple perspective explaining risk-informed/performance-based for use at consensus committee meetings.
DUE DATE: June 1, 2017

8. Exercising Practical Implications of Emerging PB Framework

Prasad Kadambi stated that a PB Framework can be used to develop a set of practices for each of the reasons and feels it would be beneficial for ANS to develop. He has prepared a PINS for this proposal. Kadambi recognized that the project would need to be assigned to a consensus committee since the RP3C does not develop standards. Ed Wallace explained that the development of a design guide is a long-term goal. One user of this guidance could be an investor group for new reactor designs.

9. Review of Open Action Items

Prasad Kadambi suggested that the slate be wiped clean on action items and start tracking action items with those assigned today as many were no longer relevant. Members asked that the RP3C Chair and Vice Chair review the list of action items (Attachment 3) to make sure none were relevant before deleting.

Action Item 11/2016-12: Prasad Kadambi and Ed Wallace to review the list of previously assigned action items to determine if any remain relevant.
DUE DATE: June 1, 2017

10. Other Business

No other business was discussed.

11. Next Meeting

The next two RP3C meetings will be held on Monday during the ANS Annual Meeting, June 11-15, 2017, San Francisco, CA, and the ANS Winter Meeting, October 29-November 2, 2017, Washington, D.C.

12. Adjournment

The meeting was adjourned.

Action Item List

Note: Action items are closed once discussed at a meeting with agreement of the membership

Action Item	Description	Responsibility	Status
11/2016-01	Ed Wallace to provide Mark Linn specifics on the SAP so that his working group can populate a SAP for ANS-30.1. DUE DATE: N/A)	N/A	N/A
11/2016-02	Mark Linn and the ANS-30.1 Working Group to develop a SAP. DUE DATE: N/A1)	N/A	N/A
11/2016-03	Wallace to provide the list of participants in the Southern Company project on the modernization of technical requirements for licensing on nonlight water reactors. DUE DATE: June 1, 2017	Wallace	OPEN
11/2016-04	Prasad Kadambi to check with the Standards Board to see if the RP3C Bylaws should be expanded to permit the development of a process standard. DUE DATE: June 1, 2017	Kadambi	OPEN
11/2016-05	Prasad Kadambi to check with the Standards Board to see if RP3C is allowed to address the questions coming out of the licensing-modernization project. DUE DATE: June 1, 2017	Kadambi	OPEN
11/2016-06	Mark Linn to provide the current draft of ANS-30.1 to Pat Schroeder along with an explanation of the feedback he needs. DUE DATE: December 1, 2016	Linn	OPEN
11/2016-07	Pat Schroeder to issue the ANS-30.1 draft to RP3C for comment. DUE DATE: December 1, 2016	Schroeder	OPEN
11/2016-08	RP3C to provide feedback to Mark Linn on the ANS-30.1 draft. DUE DATE: January 15, 2017	RP3C	OPEN
11/2016-09	RP3C/Prasad Kadambi to prepare a one-pager to summarize a PB Framework. DUE DATE: April 1, 2017	Kadambi/RP3C	OPEN
11/2016-10	Consensus committee chairs to review the PB Framework white paper once developed. DUE DATE: May 1, 2017	Consensus committee chairs	OPEN
11/2016-11	RP3C to prepare a brief, five-slide presentation with a simple perspective explaining risk-informed/performance-based for use at consensus committee meetings. DUE DATE: June 1, 2017	Kadambi/RP3C	OPEN
11/2016-12	Prasad Kadambi and Ed Wallace to review the list of previously assigned action items to determine if any remain relevant. DUE DATE: June 1, 2017	Kadambi, Wallace	OPEN

ANS Standards Committee RP3C Meeting

Las Vegas, NV
November 7, 2016

Agenda

1. Welcome, Roll Call & Introductions
2. Approval of Meeting Agenda
3. Review & Approve of June 13, 2016, RP3C Meeting Minutes
   - Broader Implications of DB-BDBE Work
4. RP3C's Roles, Responsibilities & Evolution
   - Review Standards Board Meeting
   - Strategic Gaps and Addressing Them
5. Interactions with Working Groups
   - ANS-30.1, ANS-2.8, ANS-51.10
   - JCNRM's SCoRA
6. Standardization of PB Consideration of Licensing Basis
   - Licensing Basis Regions (Reference to ANS-2.8)
7. Exercising Practical Implications of PB Framework
   - Proposal for Advanced Reactor Design Practices Guidance
8. Open Items & Action Items
9. Next Meeting, Adjournment
   - ANS Annual Meeting, June 11-15, 2017, San Francisco, CA

June 2016 RP3C Meeting Discussion Items
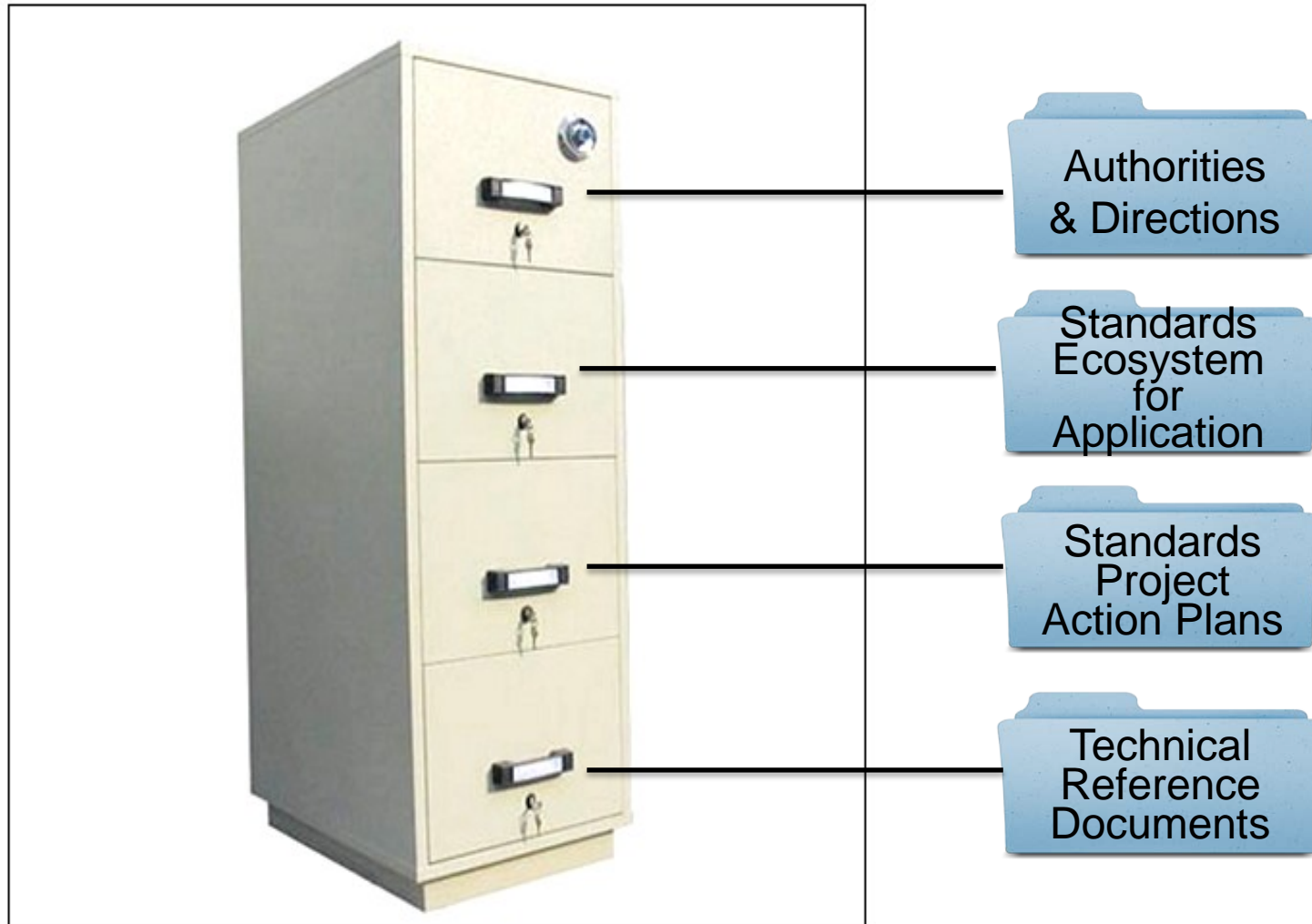
- **The Standards Application Platform Concept**
  - A Structured Knowledge Base
  - RIPB and Integrated Decision Making
- **Proceeding to Application**
  - Proposal with respect to ANS-30.1
  - Consideration of ANS-30.2
- **DB-BDBE and a PB Framework**
  - Safety Cases and GSI-191
- **Moving to Design Guidance**
  - Scenario Based Design Decisions to Support Licensing Bases

Example RIPB Standards Application Platform for RARCC

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Authorities & Directions

Standards Ecosystem for Application

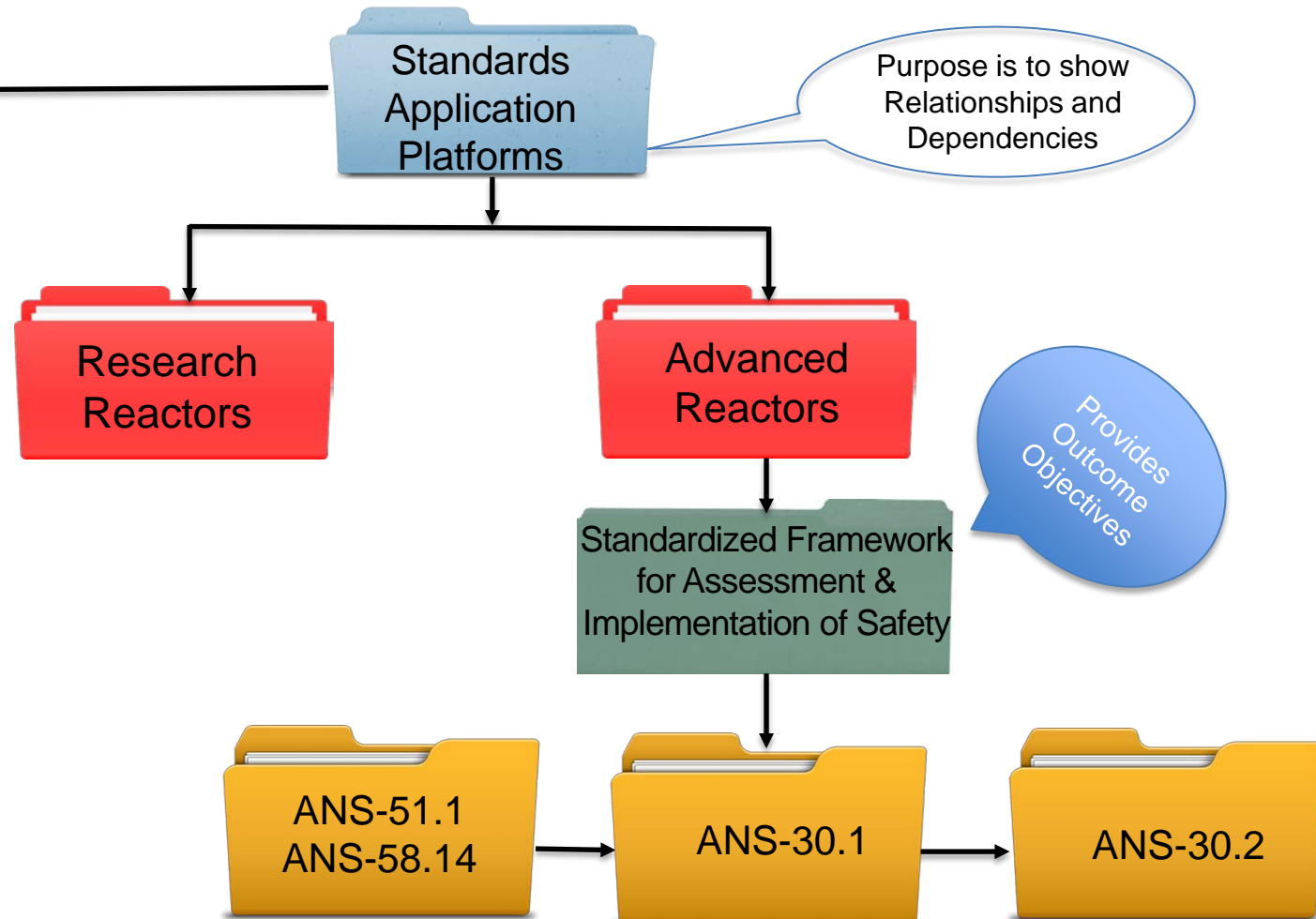Standards Project Action Plans

Technical Reference Documents

Example RIPB Standards Plan for RARCC

Standardization of BDB Evaluations

- Outcome objectives from SB (reproduced for reference)
  - A consistent approach needs to be developed for addressing BDBE in standards in the future.
    - The development of this approach needs to consider risk and performance
    - Address the spectrum of potential transients and events from a common, overall perspective.
    - Is the term BDBE a misnomer because designs have BDBEs?
  - Our approach needs to recognize that the design for systems and equipment whose sole purpose is to protect the public from very low probability events do not have to meet the same design criteria as those that mitigate more probable events in order to assure a high level of safety.
- Outcome objectives to be translated into Safety Case
  - Proposed next activity of TG
  - Will use email discussion in Workspace (RP3C on copy)

7

Standardization of BDB Evaluations (contd)

- The following are offered as starting points for TG discussion
- Differentiating DB and BDB
  - Consider range of possibilities: eg. Licensing Basis equals (DB+BDB)
  - DB has legal implications that would not apply to BDB
  - Formal differentiation on the basis of quality and magnitude of safety margin
- Principal Design Criteria based on DB
  - Quality of safety margin relies on safety grade classification or special treatment
  - Magnitude of margin based on conservative analysis
  - DiD relies on single-failure analysis at component and system level

8

Standardization of BDB Evaluations (contd)

- DiD may be an outcome objective for BDB Evaluations
  - Single failure criterion applied at the functional level
  - Consistently employs best estimate analysis
- Standardization is in the process approach
  - Process is performance-based per NUREG/BR-0303
  - Safety case function like objectives hierarchy
  - Formal representation of safety margin, including temporal margin is needed
- A process standard presumes that conformance with process equals outcome predictability and confidence
  - Converse also applies
    - Specific non-compliance with process element equals outcome failure

9

Standardization of BDB Evaluations (contd)

- Recent NRC decisions useful for standardization
- NRC has accepted PB treatment for ROP-SDP involving mitigating strategies
  - Deals with performance deficiencies of low safety significance
  - As a PB matter, safety margin is maintained
- NRC accepts GSI-191 resolution using BDBE approach
  - SRM to SECY-2010-0113
  - Spells out safety case

6

10

Think about "safety case" for "beyond-design-basis events" (BDBE)

- DB is the region of issue space within which our model is validated, and barriers are known to be OK.

- BDB is the region of issue space in which we are no longer sure barriers are OK; either we are unsure, or we know that one or more is failed.

- Beyond the above definitions: the present suggestion is to encourage a certain desirable property of the design itself: it should be demonstrably true that the frequency of crossing the DB to BDB boundary is very low.

  - This places conditions on the model (validatability) and on the design itself.

  - There should be significant probabilistic margin to crossing that line.

- The reliance on BDB features can be less as compared with DB, and this is justified up to a point by the low challenge frequency.

- The "DB" and "BDB" regions are defined based on physical characteristics of the scenarios, and on whether the model is validated, and **not on event frequency categories chosen *a priori*.**

Reasonable Assurance of Adequate Protection

ANS

Prevent Releases:
Achieve an extremely low frequency of excursions beyond [orange-red boundary]

Notion:
"very low" * "low" ~ "extremely low"

Achieve a **very** low frequency of excursions beyond [yellow-orange boundary]

Achieve a low frequency of excursions beyond [orange-red boundary] **given** entry into orange

Cornerstones — INITIATING EVENTS → MITIGATION SYSTEMS → BARRIER INTEGRITY
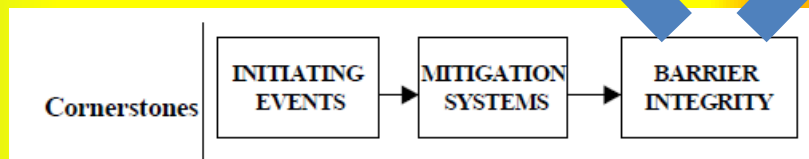
Model is rigorously validated

Not practical to validate model to the same degree

Simulation Model is *Practical* to validate

Simulation Model gets *Harder* to validate

SSCs qualified for the environments that they see   **AND**

Geometry intact: no breached barriers (only VERY minor leakage), no significant change in fuel geometry [for solid fuel types], …   **AND**

Only limited chemical reactions or changes in composition   **AND**

No new phases   **AND**

Simulation model is validatable at the system level   **AND**

Success paths can be shown to have margin: SSCs individually have margin to failure, capability > success requirement

SSCs **NOT** qualified for the environments that they see   **OR**

Geometry **NOT** intact: breached barriers (> VERY minor leakage), significant change in fuel geometry [for solid fuel types], …   **OR**

Chemical reactions or changes in composition   **OR**
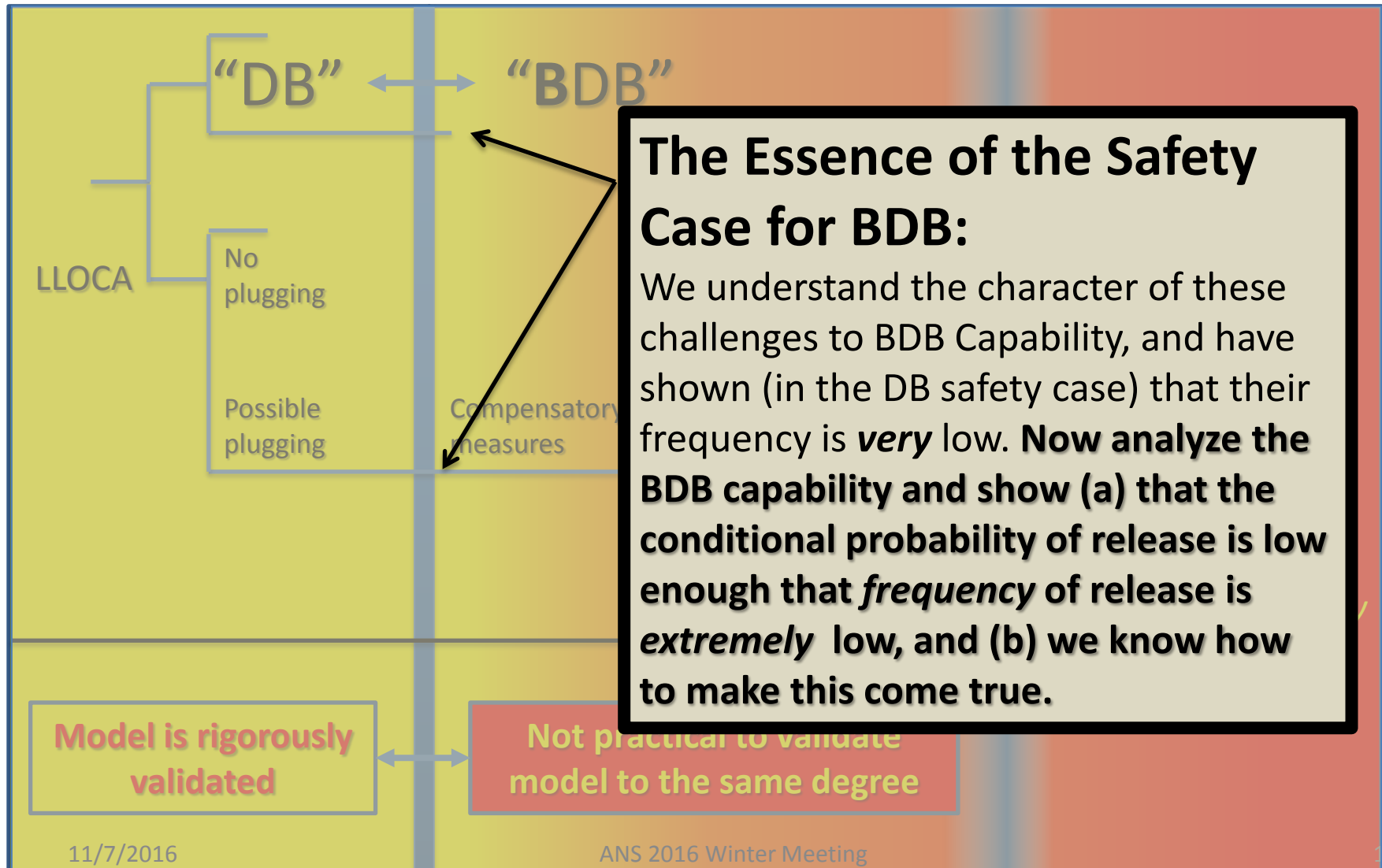
New phases   **OR**

Simulation model is **NOT** validatable at the system level   **OR**

Success paths can **NOT** be shown to have margin (not all SSCs individually have margin to failure; some may have failed)

Show that the frequency of crossing this threshold is **very** low

Argue that the **conditional probability** of crossing this threshold is "low," and therefore the **frequency** of crossing this threshold is *extremely* low

"DB" ← → "BDB"

LLOCA

No plugging

Possible plugging

Compensatory measures

The Essence of the Safety Case for BDB:

We understand the character of these challenges to BDB Capability, and have shown (in the DB safety case) that their frequency is *very* low. **Now analyze the BDB capability and show (a) that the conditional probability of release is low enough that *frequency* of release is *extremely* low, and (b) we know how to make this come true.**

Model is rigorously validated

Not practical to validate model to the same degree

Example Outcome Objectives for Advanced Reactor Design

- Design decisions for advanced reactors are based on optimizing performance to support safety, economic, and societal objectives.
  - If regulatory precedents need to be considered, the costs of doing so will be balanced against the compromises needed relative to the main objectives.
- The assessment of effectiveness relative to accomplishing the above objectives will be part of the designer's decision making framework.
  - Assessment methods are commensurate with the importance of the design decisions relative to the functional objectives.
- Implementation decisions will focus on maximizing the benefits related to the technology in question.
- The level of risk associated with unknown factors would be subject to the designer's articulation of "how safe is safe enough (HSISE)."

RP3C Roles & Responsibilities

Excerpt from Charter

The RP3C is responsible for the identification and oversight of the development and implementation of the ANS Risk-Informed and Performance-Based Standards Plan that establishes the approaches, priorities, responsibilities and schedules for implementation of risk-informed and performance-based principles in American Nuclear Society (ANS) standards. These principles are applicable to standards that address the design, construction, operation, evaluation and analysis, decontamination and decommissioning, waste management, and environmental restoration for nuclear facilities. The RP3C is not authorized to develop consensus standards or other similar products.

The RP3C is also responsible for reviewing standards being developed by other standards developing organizations as assigned by the ANS SB on related topics to ensure consistency.

Consensus Committees and Standards Application Platforms

- Purpose
  - Knowledge management
- Outcomes
  - Improved interfacing standards coordination
    - Internal to ANS standards
    - Interfaces with external standards
  - Improved understanding
    - More accessible development history
    - Improved access to references
  - More efficient development
  - Better maintenance accountabilities
- Structured for content population
- Facilitate strategic communications
- Promote strategic initiatives for growth

The Strategic Imperative

- **Distinguish strategy from tactics (action plans)**
  - Strategy implies direction-setting and a hierarchy of goals and objectives.
    - A hierarchy is needed to capture time, scale, scope, and relationships of different combinations of qualitative and quantitative acceptance criteria at various levels of the hierarchy.
- **The strategic role of voluntary consensus standards (VCSs)**
  - In the US, the role of VCSs has significance on the basis of NTTAA and OMB A-119.
  - Globalization of nuclear technology and its commercial success is inhibited by lack of VCSs and supporting conformity assessment practices.
    - VCSs play an important role in preventing national protectionist trade practices.
    - VCSs can play an important role in protecting intellectual property rights.
  - There is a need for the ANS SB to explore the possibility that VCSs have a place in every division and Standing Committee of the ANS fulfilling its own strategic objectives.
- **Flexibility and performance-based approaches**
  - VCSs that incorporate flexibility reduce costs
  - The central purpose of a performance-based approach is to offer flexibility in accomplishing objectives.
  - An important secondary purpose is to include positive incentives for actual safety improvements.

Interactions with WG for ANS-2.8

- **Purpose:** Criteria to establish design basis flooding for nuclear safety-related features at nuclear facilities. Evaluate floods caused by
  - precipitation and snowmelt,
  - dam failures & seismically-induced dam failures,
  - surge or seiche and attendant wind-generated wave activity, and
  - a reasonable combination of these events.
- Criterion is to have virtually no risk of exceedance.

RP3C Actions and Conclusions

- Prasad Kadambi, Robert Youngblood, & Alan Levin assigned to review draft document.
- Question regarding design basis from PFHA.
- Question whether FHSA would consider scenario based approach proposed by RP3C.
- Response indicated need to proceed expeditiously and that DB was not intent.
- Intended for licensing bases for range of facilities.
- FHSA considers "probability of exceedance for the flood hazard (including relevant associated effects) is less than a threshold probability."

Interactions with WG on ANS-51.10, "AFW Systems…"

- About ANS-51.10
  - Originally issued in 1979.
  - Version in 1991 incorporated SBO requirements.
  - Current version includes defense-in-depth, diversity of power sources and PRA language.
- Commentary on draft provided by members of SB, JCNRM, and RP3C.
- JCNRM offered editorial comments and did not recommend making standard risk informed.

RP3C Comments and Conclusions

- Agreed that making ANS-51.10 risk informed is not feasible.
  - Performance criteria well established with exception of reliability and availability.
  - Showed lack of consensus on "risk-informed," "deterministic," "prescriptive" requirements.
  - It is feasible to make the requirements performance based.
- Scenario-based technical basis can address defense-in-depth.
  - "Feed-and-bleed" DHR functional capability adds to single-failure proof DB.
  - Standard addresses other defense-in-depth scenarios.
- RP3C recommends that future revision of ANS-51.10 be performance based.

Observations from WG Interactions

- RP3C has been intending to demonstrate use of RIPB principles using ANS-30.1 as a pilot.

- As reported in June 2016, it is not clear that this effort will be successful.

- It may be better to consider a different standard or a new standard.

- Given the constraints on RP3C's role and assigned responsibilities within the ANS Standards Committee, we may wish to propose ANS-30.2 and/or a new design practices guide.

Observations from WG Interactions (cont'd)

- RP3C has drawn important lessons from working with the revisions to ANS-2.8 and ANS-51.10.
- From working with ANS-2.8, it is clear that the distinctions on performance criteria applicable in DB and BDB regions would be important.
  - Flood sources may be deterministically bounded.
  - Flood sources may be probabilistically bounded.
  - Type of facility determines design basis frequency targets.
- The safety case would likely argue that certain issues do not need explicit treatment of uncertainty.
  - Prescriptive requirements would likely apply for the deterministically bounded hazards.
  - PB requirements would be justified for the probabilistically bounded hazards.
- The designer decides which SSCs fall where.

Observations from WG Interactions (cont'd)

- ## ANS-51.10 addresses a different set of safety challenges.
  - Criteria for AFWS would be established through a risk-informed process to optimize functional performance but could be imposed prescriptively or in a PB manner.
  - For operating plants, oversight can be, and due to ROP is, performance based.
  - If the designers of AFWS used a scenario basis, the entire function of DHR could have been made PB and would likely have been less prescriptive.

A Standardized PB Framework

- What is emerging is that RI is useful in certain areas but opportunities for PB are more abundant.
- Prescriptive and deterministic requirements are likely beneficial for some DB considerations.
- A designer could choose to assure safety margins using a PB approach.
- Reliability of safety outcomes is the main consideration.
- Available PB approach requires suitable parameters for performance observation and measurement.
- It also requires an appropriate monitoring system.

The General Idea

ANS
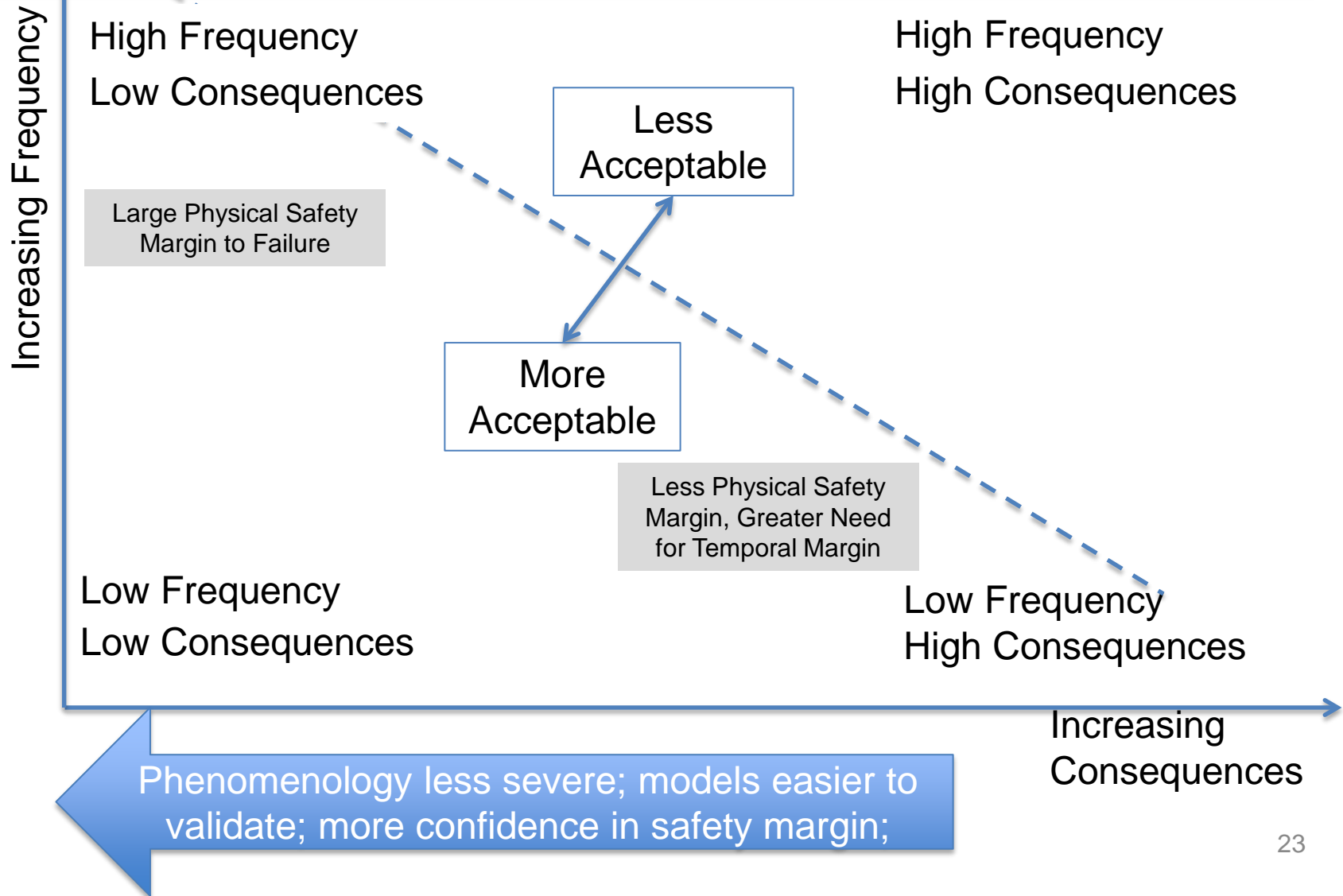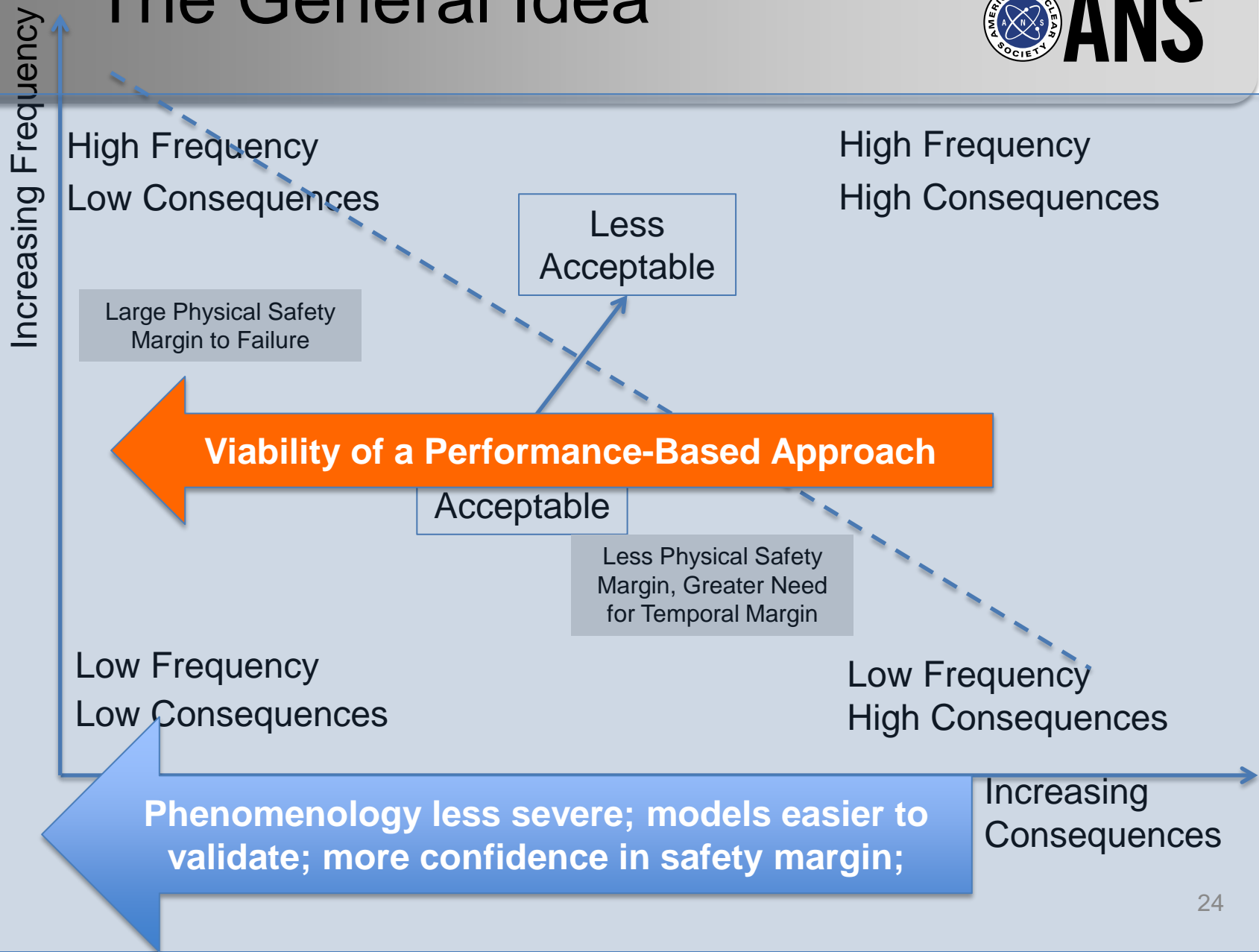
Increasing Frequency →

High Frequency
Low Consequences

High Frequency
High Consequences

Large Physical Safety
Margin to Failure

Less
Acceptable

More
Acceptable

Less Physical Safety
Margin, Greater Need
for Temporal Margin

Low Frequency
Low Consequences

Low Frequency
High Consequences

Increasing
Consequences →

Phenomenology less severe; models easier to
validate; more confidence in safety margin;

23
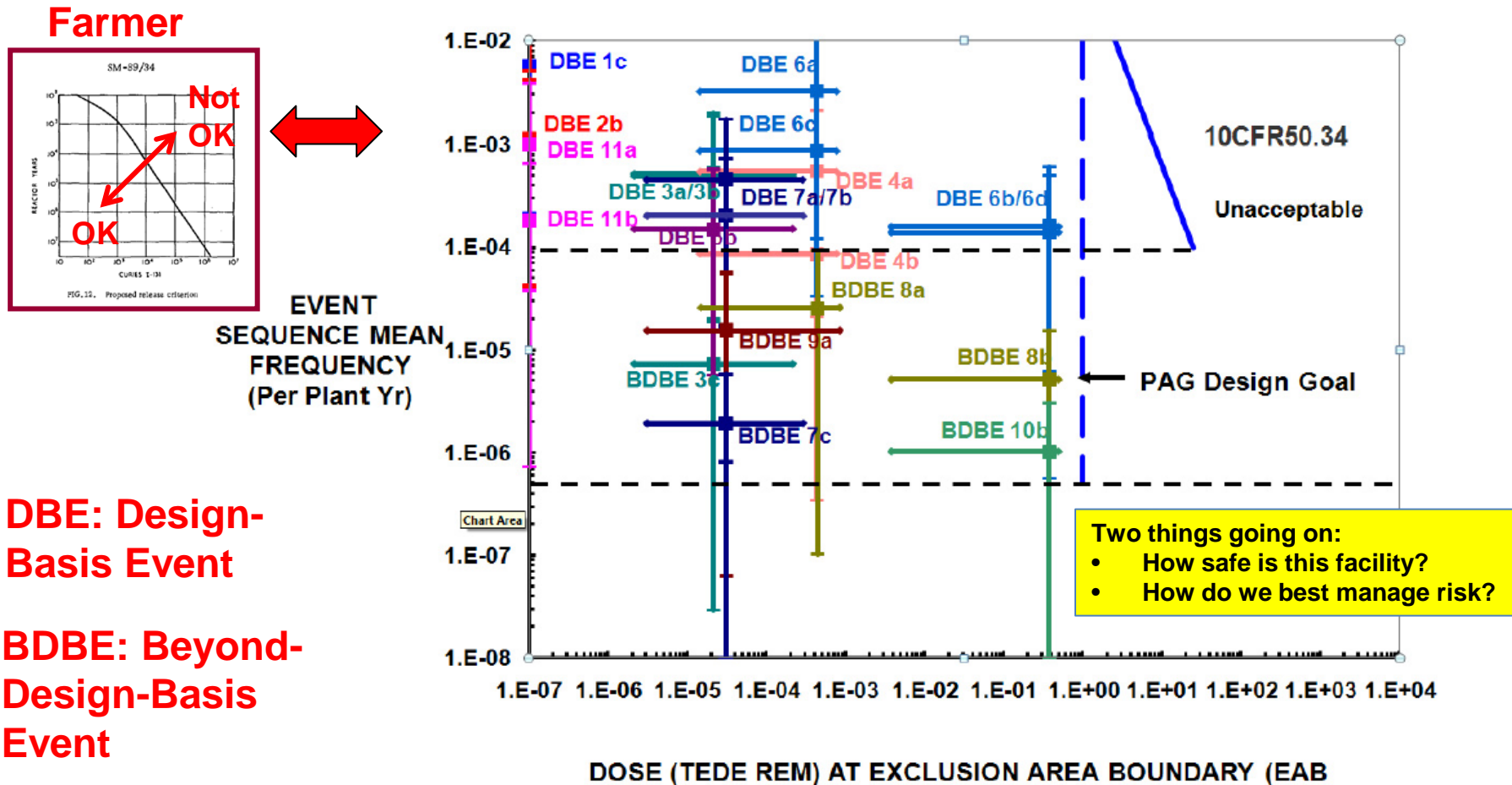
Figure 8. Use of PRA to select BDBEs.

Scenario-Based Performance Requirements

- An accident sequence that begins in the DB range can be followed through postulated failure progression.
- In the NGNP example, Event Sequence #7 begins as a DBE and progresses to a BDBE.
- Similar to the GI-191 case, crossing of the threshold between DB and BDB represents a drastic change in the associated frequency of occurrence.
- Hence, a PB framework that recognizes a graded approach would associate different requirements of validation rigor and conservatism of analysis.
- The specific performance measures and criteria would be technology and design dependent.

Performance-Based Framework
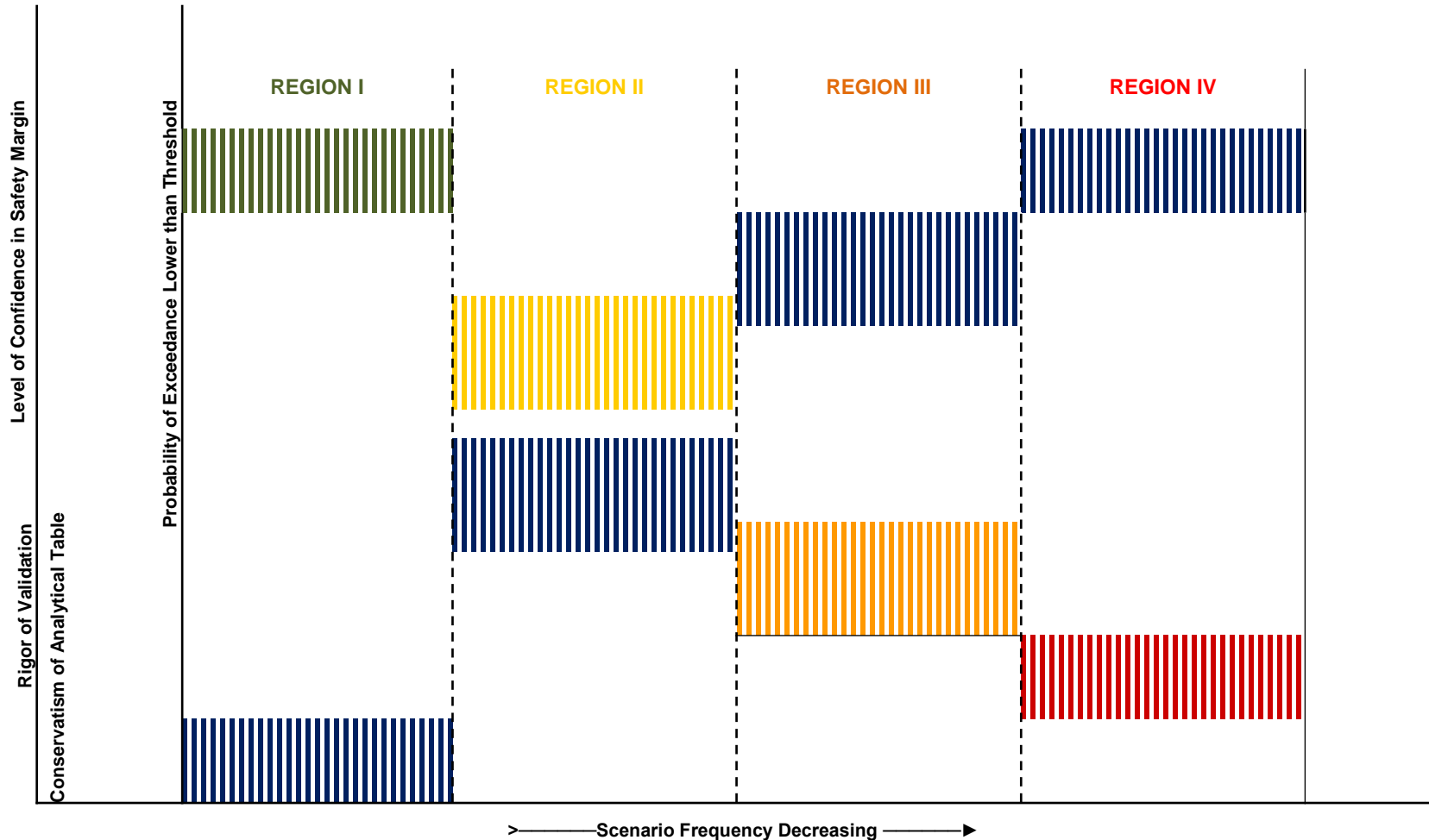
Performance Measures and Attributes

- PB framework based on NUREG/BR-0303 would consider safety margin as a performance measure in a scenario-based system.

- The safety margin can be defined in a graded manner dependent on whether DB, BDB, or residual risk is being considered.

- The gradation can be on the basis of level of confidence in the safety margin based on rigor of validation and/or conservatism of the analysis.

- The performance measure can also include the acceptable level of the probability of exceedance.

- A graded approach could consider as acceptable lower confidence levels in the safety margin as scenario frequency decreases.

- Similarly it may be acceptable to have increasing levels of probability of exceedance given a threshold being set.

- The PB framework would provide the designer flexibility to fulfill the attributes in the most economical manner.

Application to ANS-2.8

- ANS-2.8 envisages a wide variety of scenarios.
- Safety category
  - SC-1 for reactors or similar facilities
  - SC-2 for "medium or intermediate" consequences
  - SC-3 for "low" severity consequences
- Hazard complexity
  - Based on level of effort and severity of hazard
- Screening analysis to screen out scenarios
  - Qualitative screening
  - Deterministic bounding
  - Probabilistic screening
- Annual exceedance probability
  - "virtually no risk of exceedance"
- The framework for ANS-2.8 could be made more PB and less subjective by enabling use of performance measures that capture scenario attributes.

Proposal to Implement PB Framework

- A draft PINS Form has been prepared proposing a designers' practices guide.
- Suggested to contain technical practices to be used by advanced reactor designers to assess and implement safety.
- The technical practices would parallel regulatory practices regarding principles and policies.
- The integrated decision making framework (IDMF) would define how results from technical practices support higher level objectives.
- Logical continuity between results of practices and outcome objectives is a characteristic of the IDMF.
- IDMF can address multiple top level outcomes such as safety, economics, and societal concerns.

Optimizing Performance Objectives Between Multiple Outcomes

- Consider outcomes related to safety, economics, and public acceptance.

- A designer is concerned about all three, but a framework does not exist to perform trade-offs transparently.

- The practices guide would provide top-down (IDMF) and bottom-up guidance among multiple hierarchies.

- An outcome objective for the guidance is that traceability and trackability would be available.

- Relationship between design practices and associated regulatory practice is based on functional analysis.

Designers' Outcome Considerations

- Safety
  - Functional adaptation of regulatory criteria based on principles and policies
  - Focus on enhancing benefits of technology
  - Focus on innovative methods and tools
- Economics
  - Consider practices more broadly beyond nuclear practice
  - Discrepancies reconciled through IDMF at levels above practices.
  - Discrepancies within nuclear technology would invoke NUREG/BR-0058, "Regulatory Analysis Guidelines."
- Public Acceptance
  - Involves local considerations and value judgements
  - Likely to primarily involve region of residual risk
  - May involve notions of defense-in-depth and HSISE

Action Item Status

- Action Item 6/2013-01: Kadambi to update and distribute next draft of the Risk-Informed and Performance-Based (RIPB) Plan with member comments incorporated. (RIPB Plan renamed RP3C Vision Plan.)
- Action Item 6/13-05: Kadambi to prepare a note on weaving RIPB ideas into Tier 3 issues as defined by NRC.
- Action Item 6/13-07: Kadambi to prepare a note on how consensus standards activities can help address long standing issues regarding defense-in-depth (DID).
- Action Item 11/2013-01: George Flanagan to provide Mark Peres a copy of the current ANS-54.1 draft for an example.
- Action Item 11/2013-02: Amir Afzali to provide George Flanagan the name of Southern Nuclear Company's technical expert to help on ANS-54.1.
- Action Item 11/2013-03: Amir Afzali to provide suggestions on how the RP3C Vision Plan can emphasize safety.

Closing

ANS

- **Other Business**
- **Next Meetings**
  - ANS Annual Meeting, June 11-15, 2017, San Francisco, CA
  - ANS Winter Meeting, October 29-November 2, 2017, Washington, DC

- **Adjourn and Thank You!**

BACKUP

BACKUP
&
BACKGROUND
SLIDES

RP3C Roles & Responsibilities (cont'd)

What is needed?

- We need comprehensive, yet application specific information on the state of ANS standards and needs in the context of the standards ecosystem
- We need to be able to assess capabilities of existing standards and identify what is missing relative to a specific area of application.
- We need to be able to envision and articulate outcome objectives that support RIPB goals within the defined area of activity
- We need to be able to identify and gain consensus on the functional accomplishments that are necessary and sufficient to achieve the outcome objectives
- There should be technical expertise to identify and understand standards from a wide range of relevant standards developing organizations (SDOs)
- We need to recognize that SDOs work independently but are generally open to discussion and negotiation.
- We need the Standards Board to help us achieve the goals in each activity area.

BDB scope

- BDB scope:
  - The demonstration (arguments, evidence) that given an entry into the orange zone from the yellow zone, the plant will almost surely not go into the red zone.
  - Understanding of SSC attributes (and corresponding special treatment) needed to make this come true.
- Entry into the orange means that something bad has happened
  - Some sort of failure has occurred (refer to earlier slide offering notional definitions of yellow and orange)
- Uncertainties of various types will be much larger in the orange zone than in the yellow zone.
- Models are harder to validate in the orange zone.
- ***But this is partially compensated by the demonstrated low frequency of entering the orange zone***

Example Considerations Re. "Issue Spaces"

- The DB (green) issue space is characterized by maximization of safety margins by employing the full range of component special treatments (quality, pressure retention, seismic, and environmental) along with conservative assessment methods
  - The designer has the incentive to capture as much of the uncertainty relative to HSISE within the green region
- The BDB (yellow) region is characterized by cost beneficial safety enhancements
- The BDB (orange) region is characterized by event sequence frequencies at the higher end of HSISE
- The BDB (red) region is characterized by event sequence frequencies at the lower end of HSISE
- The designer does not have to set HSISE limits

RIPB Management Framework

Suitable combination of processes to:

1. Model systems and assess risk
   a) Risk need not always involve exposure to radioactivity
   b) Risk can also be defined in terms of failure to meet objectives
   c) How much PRA quality is sufficient to know this?
   d) Success can be defined as adequately low probability that an outcome will not be achieved

2. Specify and monitor performance objectives
   a) A suitable combination of objectives constitutes an outcome
   b) A successful outcome can be defined as a high enough probability that a specified set of objectives will be achieved

3. Conduct integrated decision-making
   a) Multi-attribute decision-making under uncertainty is a recognized part of decision theory disciplines
   b) A process with well defined success criteria involves a structured set of activities, each of which is characterized by a suitable set of qualitative and quantitative observable parameters.
   c) How likely is it that parameters observed are acceptable but outcome is unacceptable? (See NUREG/CR-6833)

Principles and Policies

Principles	Policies
• **Licensed activities must be conducted with "no undue risk"**	• Assure low probability of accidents that can adversely affect health and safety
• **Experience with operational facilities shows "no undue risk" criteria met with deterministic approach that considers safety margins, uncertainties and defense-in-depth**	• Probabilistic methods should be used to complement deterministic approaches to improve safety and incorporate realism and more efficiently assure "no undue risk" .
• **The regulated community assures safety by conforming to requirements developed by an independent regulatory authority through open and participatory processes such as rulemaking, licensing, inspections and assessments (collectively called the Regulatory Framework).**	• Voluntary consensus standards developed with duly accredited processes are an effective adjunct to regulatory requirements, and should be relied upon to improve the efficiency and effectiveness of implementing safety requirements.
• **Implementation of "no undue risk" can be pursued with a wide range of methods involving probabilistic approaches which fall under the discipline of decision-making under uncertainty.**	• Constructing a PRA is just one of the approaches for implementing probabilistic methods, and other methods should also be examined for risk-informed options.

Steps for Performance-Based Approach Implementation
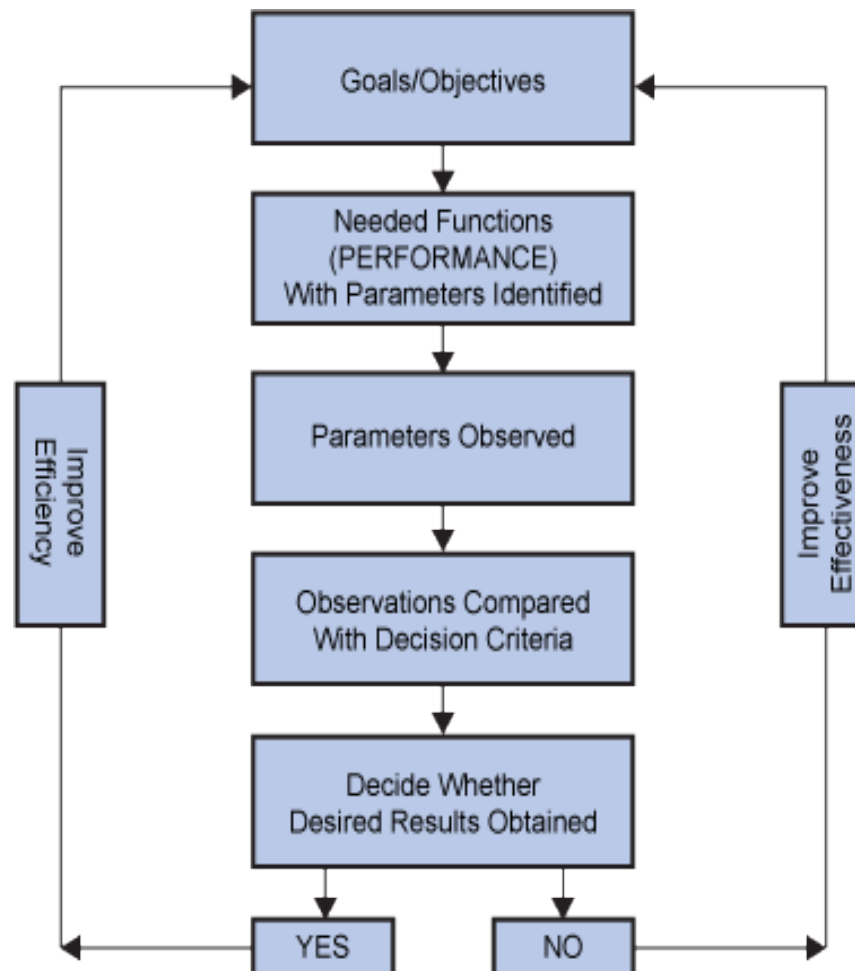
RIPB Decision Framework

- Source: RG 1.174

- Basis for binning

- Can a change impact licensing basis?
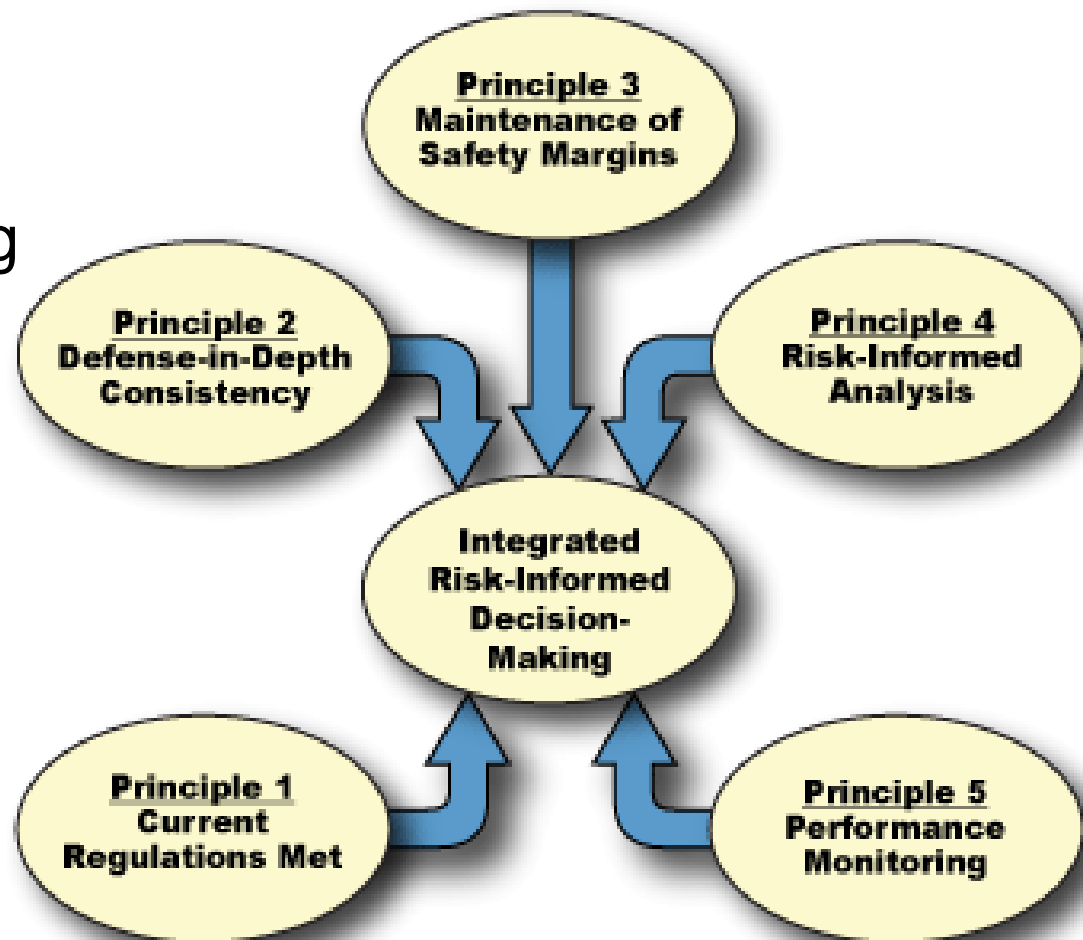
Modernization of Technical Requirements for Licensing of Non-Light Water Reactors

Amir Afzali

Licensing and Policy Director - Next Generation Reactors, Southern Nuclear and NEI ARRTF Co-Chair

Introduction

- Modernization of current requirements is necessary
  - Current framework primarily LWR-based
  - Inherent/passive safety → significantly different characteristics
  - Risk-informed and performance-based (RIPB) → realization of enhancements in safety
- Process attributes
  - Technology-inclusive (TI)
  - RIPB
  - Collaborative development
  - Build on substantial precedent and recent NRC *Vision and Strategy*

Industry Interfaces

Project Inputs and Products

Previous efforts (e.g., NGNP Project, PRISM, NUREG-1226, ANS 53.1)

International Efforts

Input from Owners and End Users and Other Stakeholders

Utility-Led Licensing Modernization Project

Example Applications

Proposal(s) for TI RIPB Technical Requirements to NRC

Input for Analytical Tools/Software to National Labs/EPRI

Input for Standards to Standards Development Organizations

Project Deliverables Master Logic

PRA Related Precedent Review [incl. in 1.1.1]	→	Independent Review of NGNP WP on PRA and LBE [4.6]	→	PRA Utilization in Design and Licensing (Roadmap) [4.2]		

	Define PRA Scope/Objective for PB-RI Licensing Applications [4.1]	→	Use of PRA for LBE Selection [4.4.1]	→	PRA Technical Adequacy Requirements [4.4.2 - 4.4.5]	→	Use of PRA for LBE WP

| LBE Related Precedent Review [incl. in 1.1.1] | → | LBE Gap Analysis [1.3.2.1] | → | Define PB Technical Requirements [1.2] | → | Refined Definitions [1.4.2.1] | → | LBE Selection WP |

| Performance-Based Precedent Review [incl. in 1.1.1] | → | Review ARDC Results [1.3.1] | → | Review Other Advanced Reactor Gap Analysis | → | Conduct Non-LWR Total Regulatory Gap analysis [1.3.2.2] | → | WP on PB Criteria for Non-LWR's |

| | RIDM Precedent Review [incl. in 1.1.1] | → | Select/Develop RIDM Methodology [1.4.1] | → | RIDM Acceptance Considerations [1.4.2] | → | WP on RIDM Standardized Process |

| Precedent Review [incl. in 1.1.1] | → | Independent Review of NGNP WP on SSC Safety Class. and DID | → | Summarize Examples of PRA's to Risk-Inform Design [4.3] | → | Define Tech. Issues for non-LWR PRA's in support of PB-RI Licensing [4.5] | → | WP of PRA for RIDM beyond LBE Selection |

| Develop List of potential Pilots (PRA and Regulatory) | → | Assemble Lessons learned from Existing Pilots (PRA and Regulatory) | → | Establish Plan/Schedule for Pilots (PRA and Regulatory) | → | Execute Pilots (PRA and Regulatory) | → | Technical Report on Pilot Projects |

| Develop AT Requirements | → | Assess state of AT's and Availability of Validation Data | → | AT Gap Analysis Report | → | AT Gap Closure Plan | → | Technical Report on AT Software |

| | | Precedent Review [incl. in 1.1.1] | → | Summarize Usefulness for future non-LWR licensing needs [1.1.2] | → | Tech. Report on Lessons Learned from Other Precedents |

Legend

Work Package [WBS Code]	(Work Package)
Deliverable	(Deliverable)

Identify Policy Issues [1.5]	→	Policy Question Resolution (Phase 3)

Alignment of Products with RIPB Approach

- What must be met
  - Top Level Regulatory Criteria (TLRC)
- When TLRC must be met
  - Risk-informed Licensing Basis Events (LBEs) selection
    - LBE Process White Paper projected completion 2Q CY2017
    - PRA Technical Adequacy for LBE and Road Map projected completion 3Q CY2017
- How TLRC must be met
  - Process for Safety Functions Determination and SSC Classification - Design specific based on design features; to be addressed by advanced reactor designers
    - PRA Technical Adequacy for RIPB Decision Making projected completion 4Q CY2017
  - Safety Design Criteria (General and Regulatory Technical Requirements)-
    - Expanded TI Gap Analysis of SDC projected completion 4Q CY2016
    - Performance Based White Paper projected completion 2Q CY2017
- How well TLRC must be met
  - Quantitative SSC Design Criteria- Not within the scope of this project.
  - Regulatory Special Treatment – Not within the scope of this project.
  - Risk-Informed Decision Making (systematically addressing "adequate safety")
    - RI-DM White Paper projected completion 1Q CY2018

Risk-Informed and Performance-Based Licensing Basis Event Selection

- Why address first-
  - It is integral to the design process at all stages of development and central to NRC safety assessment process
  - It forms the underlying foundation for the safety assessment & license application
  - The current process for setting licensing basis events is design specific, ad hoc, and retrospective

Questions

RP3C Action Item List (10/10/16)

Action Item	Description	Owner	Status
6/2016-01	James August to prepare a white paper on how to develop a consistent format for risk-informed, performance-based standards.	James August	Completed White paper posted to Workspace here.
11/2015-01	Once developed, provide the RP3C a copy of the PINS form for the proposed decommissioning standard to be initiated by the FWDCC so guidance can be provided to incorporate risk-informed criteria. Due Date: January 2016	Pat Schroeder	OPEN
11/2015-02	Robert Youngblood to develop a safety case for Beyond Design Basis Events. Due date: January 2016.	Robert Youngblood	OPEN
11/2015-03	Prasad Kadambi to work with ANS staff to create a Workspace for the RIPB Application Platform to coordinate efforts more efficiently with working groups. Due Date: June 2016	Prasad Kadambi, ANS staff	OPEN
11/2015-04	Prasad Kadambi to report how RP3C will expedite their guidance criteria for consensus committees to utilize RIPB guidelines. Due date: June 2016 Meeting	Prasad Kadambi	OPEN
6/2015-04	Amir Afzali, Steven Stamm, and Pat Schroeder (and others to be recruited) to prepare the ANS Standards Application Platform aspects of the RIPB plan (implementing guidance)	Amir Afzali, Steven Stamm, Pat Schroeder	OPEN
6/2015-06	Amir Afzali, Alan Levin, and Ed Wallace to form a task force to provide support to ANS-30.1, "Integration of Risk-Informed, Performance-Based Principles and Methods into Nuclear Safety Design for Nuclear Power Plants." (Standards Board Action Item 11/2014-20)	Amir Afzali, Alan Levin, Ed Wallace	OPEN
6/2015-07	Prasad Kadambi, Robert Youngblood, and Gerry Kindred to develop guidance for addressing BDBEs in future ANS standards. (Standards Board Action Item: 11/2014-11) Due by November 2015.	Prasad Kadambi, Robert Youngblood, Gerry Kindred	OPEN
6/2014-02	Ed Wallace and Prasad Kadambi to update the policy on developing risk-informed and performance standards.	Ed Wallace, Prasad Kadambi	OPEN
11/2013-03	Amir Afzali to provide suggestions on how the RP3C Vision Plan can emphasize safety.	Amir Afzali	OPEN
11/2013-06	James O'Brien to lead an ad hoc group to review classification methods to determine if a standardized approach is possible; Donald Spellman to provide support.	James O'Brien, Donald Spellman	OPEN
11/2013-10	Prasad Kadambi to prepare a white paper with guidance on risk informing a standard. NOTE: Mark Peres is no longer on the RP3C and was removed from the action item.	Prasad Kadambi	OPEN