American Nuclear Society

MINUTES

Risk-Informed and Performance-Based Principles Policy Committee (RP3C)

Hyatt Regency New Orleans, New Orleans, LA
June 13, 2016

Members Present:
Prasad Kadambi, RP3C Chair, Individual
Edward Wallace, Vice-Chair, GNBC Associates, Inc.
Amir Afzali, Southern Nuclear Operating Company
*James August, Southern Nuclear Operating Company
*Robert Budnitz, Lawrence Berkeley National Laboratory
Donald Eggett, Individual
John Fabian, American Nuclear Society
George Flanagan, Oak Ridge National Laboratory
*Gerry Kindred, Tennessee Valley Authority
Alan Levin, U.S. Department of Energy
*William Reckley, U.S. Nuclear Regulatory Commission
William Reuland, Individual
Patricia Schroeder, American Nuclear Society
Andrew Smetana, Savannah River National Laboratory

*participated by phone

Members Absent:
Wayne Andrews Jr., Individual
Edward Blandford, University of New Mexico
Richard Browder, Duke Energy
Robert Busch, University of New Mexico
Gene Carpenter, U.S. Nuclear Regulatory Commission
Robert Eble, AREVA Inc.
Kamal El Sheikh, The Cameron Group, Inc.
Yan Gao, Westinghouse Electric Company, LLC.
Stanley Levinson, AREVA Inc.
Mark Linn, Oak Ridge National Laboratory
Thomas Marenchin, U.S. Nuclear Regulatory Commission
Ronald Markovich, Contingency Management Consulting
Carl Mazzola, Chicago Bridge & Iron Federal Services
James O'Brien, U.S. Department of Energy
William Reuland, Individual
Robert Youngblood, Idaho National Laboratory

Guests:
Ralph Hill, ASME BNCS
Jeff Mitman, U.S. Nuclear Regulatory Commission
Donald Spellman, Oak Ridge National Laboratory
Steven Stamm, Individual

1. **Welcome, Roll Call & Introductions**
   (Attachment 1: Meeting Presentation — Attachment 2: RP3C Roster — Attachment 3: Schedule of RIPB Standards)
   RP3C Chair Prasad Kadambi welcomed members and introductions were made.

2. **Approval of Meeting Agenda**
   The agenda was approved as presented.

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

A. Expectations from RP3C Charter and from Standards Board Strategic Plan
Prasad Kadambi emphasizes that the RP3C has been tasked with developing the ANS Risk-Informed and Performance-Based Standards (RIPB) Plan. This plan will establish the approaches, priorities, responsibilities and schedules for implementation of risk-informed and performance-based principles.

The Standards Board Strategic Plan assigns RP3C the responsibility to incorporate RIPB methods in ANS standards, where appropriate, by developing and demonstrating the Standard Application Platform (SAP). The RP3C is determining what is needed in the context of the standards ecosystem and need to integrate into ANS standards.

B. Outcome Objectives for the SAP
Kadambi described the SAP as an instrument available to the ANS Standards Committee. He explained that the SAP will provide a structured knowledge base needed for integrated decision making. Because the Standards Committee has a broad range of activities, it is the consensus committees that need to do most of the work with the RP3C as a resource. The SAP itself is a consensus committee compilation of information. Kadambi expected that there could be more than one SAP for a consensus committee.

Kadambi provided members a diagram of the SAP (Slide 8 of Attachment 1). He showed four virtual drawers for 1) authorities & directions, 2) standards ecosystem for application, 3) standards project action plans, and 4) technical reference documents. The idea is that the SAP is a living knowledge base to be used as working groups work through their action plans. He believes the use of the information will keep it current.

Members expressed concern with the resources needed to create and to maintain the SAP. Kadambi stated that the ANS-30.2 Working Group has already created something similar. He confirmed that there would be a separate virtual cabinet for each SAP. Ed Wallace added that, as a minimum, one cabinet was needed for each consensus committee. Kadambi stated that to make an effective RIPB application, you need integrated decision making. The kind of decision making needed for modernization requires a knowledge base that cuts across many silos. Right now, there isn't a mechanism to do this so he is proposing to develop this set of SAPs as the basis for modernization of our standards. Wallace added that developing an electronic SAP will add efficiency. Once the SAP is developed for the ANS-30.1 Working Group, it will be a framework for others to use. ANS staff will create the platform on Workspace. Each consensus committee would need to assign someone to add documents to their SAP.

Wallace stated that we should have a flow chart of how the bits and pieces fit together and that would be driven by the consensus committee. He suggested a flowchart should be one piece to be added to the SAP. Kadambi and Wallace see the SAP particularly helpful for new members to make standards development more efficient and shorten the gestational process.

Stamm questioned what documents would be within the Standards Board folder labeled "SB Strategies RARCC Scope." Kadambi explained that he would add the Standards Board Strategic Plan and the directive from the Standards Board that standards should be risk informed. He continued that part of creating the SAP is decision making. The subcommittee would need to decide. Smetana stated that the proposal was working through the process from the top down. The other option was creating the plan from the bottom up as the standard is developed. Kadambi see top-down method as being less efficient. He doesn't see the SAPs as being too difficult for staff to create the platform. Kadambi doesn't see how we can implement a decision-making process without the SAP. Stamm added that he was working on a revised flow chart of standards development that would include the related policies or procedures.

C. Construction of SAP for RARCC and ANS-30.1
Kadambi presentation provided an example of the RIPB SAP for ANS-30.1 which included related ANS drafts, ASME code case, and several IEEE standards The plan for ANS-30.1 (or other working group) would be accessible for Standards Board members should they want to check on the status. Wallace added that the organization of folders needs to be thought through.

4. Status of Interaction with the ANS-30.1 Working Group

A. RP3C Responses to Queries
Ed Wallace reported that responses to queries on ANS-30.1 were drafted focusing on technical issues. He stated that after reviewing the draft of ANS-30.1 in its current form, he didn't see that ANS-30.1 would make a good pilot for others to get the whole picture of how to prepare a risk-informed standard. Amir Afalzi agreed that ANS-30.1 would not be a good road map for risk-informing a standard. Wallace thought that some of the information in ANS-30.1 might be better placed in ANS-30.2 or possibly another new standard. Kadambi stated that the task group was engaged with the working group and would be producing options.

B. Feedback from the ANS-30.1Working Group
Without ANS-30.1 Working Group members in attendance, feedback was not provided.

5. Standardization of Beyond-Design-Basis (BDB) Considerations

A. Context of Standards Board Tasking
Prasad Kadambi explained that he was reporting on behalf of Robert Youngblood and directed members to Slide 16 of Attachment 1. The Standards Board tasked RP3C with developing a consistent approach for addressing Beyond Design Basis Events (BDBE) in standards. A subgroup of RP3C members was assigned this task. Subgroup members include Youngblood, Gerry Kindred, and himself. They attempted to answer the question from the point of view of using performance-based approaches. He explained that the approach outlined may be new for some.

B. Elaboration of the Safety Case and its Relationship to a Performance-Based Approach
Kadambi proposed that members think of it in terms of a safety case – a set of arguments made in favor of a particular approach being outcome objective driven. He explained that they were, at least for now, using "DB" and "BDB," to mean the following:

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

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

BDB is different than DB because not all of the methods have been fully validated. We see this as the major difference of these two spaces. Attributes can be identified with this formulation. Because there's such a distinction between DB and BDB, the frequency change from crossing this boundary is from a certain level (associated with high confidence) to one where confidence may be very low. Jeff Mitman stated that not all BDB have events that are rare. He agrees that was the intent, but they didn't always succeed. Fukushima is a good example.

Kadambi stated that he is working towards advanced reactor guidance and formulating what it might look like. The combination of validated models and less-validated models are the result of design decisions.
Those design decision were made based on postulated challenges. When speaking of postulated challenges in risk-informed space regarding license basis events, we have different ways of postulating such challenges for structures, systems, and components (SSCs). Looking at it from a designer's standpoint, the designer has to have determined how the assessment of the design activity will be done. The designer is also defining how success will be assessed – what kind of monitoring, what evidence is needed to support decisions, the combination of the definition of challenge of whether the model you use is validated or not, etc. The performance-based approach is important because preserving safety margins is what performance-based means. The whole point of performance is how to monitor the margins. As a result, what has become clear is that you need the validation process.

Steven Stamm questioned why it's not simple to draw a line – those above the line, are DB; those below the line are BDB. Wallace explained that in order to do what Stamm suggested, you need to have a high confidence. Uncertainty flops back and forth and needs to be assessed by the designer. Wallace provided an example used in the United Kingdom and how it was different in the United States. Kadambi explained the reasonable assurance of adequate protection (Slide 19 of Attachment 1). The construct was that the margins and validation would work so that the confidence in the margins would be the maximum in the green region and lower for other regions. He added that documenting how this is done is part of the safety-case approach. The graphic (in Slide 19) shows how to reflect the construct using the U.S. Nuclear Regulatory Commission's (NRC's) objectives hierarchy that is part of their reactor oversight program. This has to do with initiating events, mitigation systems, and barrier integrity. This is implementing a graded approach to safety.

Kadambi compared simulation models that are practical to validate versus those that are harder to validate. BDB scope is where arguments and evidence can be developed that give an entry into the orange zone from the yellow zone but will likely not go into the red zone. The safety case is where you would present the SSC attributes including special treatments to make this come true. One needs to do what one can to limit the consequences if SSC performance falls short. As you go from yellow, orange to red, the frequency of occurrence decreases. This process can be seen in ANSI/ANS-53.1-2011, "Nuclear Safety Design Process for Modular Helium-Cooled Reactor Plants." The point is that the designer faces a refutable hypothesis that we have a validated model within the DB region, and therefore, can argue convincingly that the frequency of occurrence of bad things from leaving the DB envelope is very low. This is essentially the bright line, but it is not with complete certainty. Kadambi added that Youngblood stated that we would still need to invoke a process argument to address completeness of the scenario set.

In closing, Kadambi stated that this approach is much closer to safety-case thinking than to any version of the classical prescriptive approach. The applicant figures out how to establish certain fundamental attributes and sells the demonstration to the regulator in the safety case.

C. Validation of models and relationship to safety margins (this was covered above)

D. “Issue spaces” and the relationship to a graded approach to safety (this was covered above)

E. Generic Safety Issue (GSI)-191 as an Example of a BDBE, a Safety Case, and an “Issue Space”
GSI-191 example of BDB Safety Case was provided in Slide 28 (Attachment 1). Resolution of GSI-191 involves two distinct but related safety concerns. A combination of several risk-informed options is under consideration for licensees to use for implementation, he believes. Kadambi summarized an approach from a Staff Requirements Memorandum (SRM) to SECY-10-113. This approach would allow for the practical assessment of plant design features and operator actions. Under this approach, existing plant-specific B.5.b equipment, which is already captured in each plant’s licensing basis, could be credited to mitigate the potential consequences of sump-clogging scenarios. As an element of this assessment, the staff should consider licensee Probabilistic Risk Assessment (PRA) information, if available, that assesses the full spectrum of pipe break sizes, plant-specific compensatory measures, and design features that could reduce sump clogging risk. One such study is being planned by a licensee.

6. Evolving Design Guidance: Framework, Principles, Policies

A. RP3C Deliberations
With limited time, there was no time for RP3C deliberations.

B. Lessons from Gen II Experiences
Prasad Kadambi briefly explained his view that the idea of validation has been used in an open ended way such that there is regulatory opportunity to unnecessarily ratchet up the level of validation. If the designer uses the safety case approach effectively, the arguments in favor of a graded approach to validation would be constructed with risk-informed regulatory practices in mind. NUREG/CR-6833, “Formal Methods of Decision Analysis Applied to Prioritization of Research and Other Topics,” describes the Receiver Operating Characteristics approach to hypothesis testing whereby the likelihood is estimated of being on the wrong side of a decision threshold criterion.

C. Example Outcome Objectives for Advanced Reactor Design Guidance
Kadambi directed members to Slide 34 (Attachment 1) on the example of outcome objectives for advanced reactor design. He explained that 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 should 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).

Ed Wallace added that what one is trying to do is to decide if there is enough certainty that action should be taken…How good is good enough to support a risk-informed decision? He stated that RP3C needed to make this decision to provide guidance. In the end, they are not going to be perfect.

D. Example Considerations Relative to “Issue Spaces”
Kadambi explained that if Gen II designs had constructed issue spaces optimally, there would be less argument about validation of models (and hence, technical adequacy of PRAs) than now. The

controversies regarding the adequacy of defense-in-depth are related to ineffective construction of arguments in favor of safety margins arising from redundancy, diversity, and independence within the safety case (such as it is). Difficulties with adopting 10 CFR 50.69 suggest that there may be a better way to implement a graded approach to safety.

7. Changing Environment

A. Going Forward with NUREG-2150
Prasad Kadambi reported that he and William Reckley were putting together guidance on using NUREG-2150, "A Proposed Risk Management Regulatory Framework." They will be proposing something – a white paper or possibly something else.

B. NRC-NEI Risk Informed Steering Committee (RISC)
Prasad Kadambi reported that NRC-NEI RISC met in February and May of 2016. They are wrapping up task groups on PRA uncertainty and technical adequacy. A greater focus was being put on FLEX.

8. RP3C Interfaces

A. Standards Board
Prasad Kadambi stated that he will report RP3C progress toward execution of activities to the Standards Board at their meeting the next day. He acknowledged that the RP3C will need governance help in promoting engagement with consensus committees on RIPB standards.

B. ANS/ASME Joint Committee on Nuclear Risk Management/SubCommittee of Risk Application (SCoRA)
Kadambi acknowledged that the RP3C needs clarity on obtaining PRA methodological help and clarity on roles and responsibilities of SCoRA vis-à-vis RP3C.

C. ANS Public Policy Committee
Kadambi informed members that the ANS Public Policy Committee was drafting a policy statement on RIPB.

9. Other Business

Amir Afzali questioned what was trying to be achieved in terms of the SAP. Modernization is ongoing. We need to look back at what standards have to change. He sees this as an overwhelming task. The role of standards is a tool, and we are letting the whole country down if we do not modernize. We need to determine what the customer/industry wants and work towards it. We need to establish a map to modernize standards. Afzali understands the importance of having a tool for future generations such as the SAP, but the ultimate objective is to develop standards that support the industry and the NRC. He would like standards development organizations to prepare a list of standards that need to be modernized as the first priority. Afzali sees the SAP as a distraction from what is truly needed – a framework for developing RIPB standards. Steven Stamm added that the RP3C Bylaws direct that the RP3C develops a list of ANS standards in need of risk-informing.

Afzali stated that he sees the role of RP3C to tell working groups what a risk-informed standard should look like – Chapter 1 should look like this, Chapter 2 should look like that, etc. He is not saying that a resource database like the proposed SAP would not be helpful. He pleaded with the RP3C to standardize what a risk-informed standard should look like.

As a past and current working group chair, James August stated that he understands how difficult it is to decide the layout of a standard. Ed Wallace explained that originally the intent was to use

ANSI/ANS-53.1-2011 as a format for risk-informing standards but that did not get supported. August suggested developing a guideline on how to develop a risk-informed, performance-based standard. Prasad Kadambi thought that working groups could use ANSI/ANS-53.1-2011 as a starting point and change as needed. Afzali expressed concern that working groups currently developing a risk-informed standard needed to know what format to follow right away or they would be wasting their time. Kadambi sees the structured knowledge base, the SAP, helping in this area. August suggested that a few steps would fall into place that would support developing the guidelines and offered to prepare a one-page white paper of how to do this.

ACTION ITEM 6/2016-01: James August to prepare a white paper on how to develop a consistent format for risk-informed, performance-based standards.

Ralph Hill expressed his surprise that the format for RIPB standards had not already been developed and echoed Afzali's sentiment that this was an immediate need.

10. Next Meeting

The next two RP3C meetings are expected to be held on Monday during the ANS Winter Meeting, November 6-10, 2016, Las Vegas, NV, and during the ANS Annual Meeting, June 11-15, 2017, San Francisco, CA, at the usual time from 2:30pm to 6:00pm.

11. Adjournment

The meeting was adjourned.

ANS Standards Committee RP3C Meeting

New Orleans LA

June 13, 2016

Agenda

1. Welcome, Roll Call & Introductions (10 min)
2. Approval of Meeting Agenda (5 min)
3. Review of RP3C's Roles and Responsibilities (20 min)
4. Context and Role of Standards Application Platform (20 min)
5. Description of Proposed SAP for ANS-30.1 (20 min)
6. Responding to Queries from WG ANS-30.1 (10 min)
7. Break (15 min)
8. BDB Considerations and Its Safety Case (60 min)
9. Evolving Design Guidance: Framework, Principles, Policies (20 min)
10. Changing Environment (15 min)
11. RP3C Interfaces (15 min)
12. Next Meeting, Adjournment

ANS Winter Meeting, November 6-10, 2016, Las Vegas, NV

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.

RP3C Roles & Responsibilities (continued)

Excerpt from SB Strategic Plan

- Incorporate risk-informed and performance-based methods in ANS standards, where appropriate, by:
  - Developing and demonstrating the Standard Application Platform (SAP) approach on at least one standard as a pilot effort
  - Incorporating the pilot approach and lessons learned from the approach into the Risk-Informed and Performance-Based Plan
  - Publishing a Nuclear News Article to inform other members of the Society of the benefits of this risk-informed and performance-based effort
  - Developing presentation materials that can be used to inform other industry groups as to the benefits and use of the ANS Standards Committee risk-informed and performance based standards activities

RP3C Roles & Responsibilities (continued)

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.

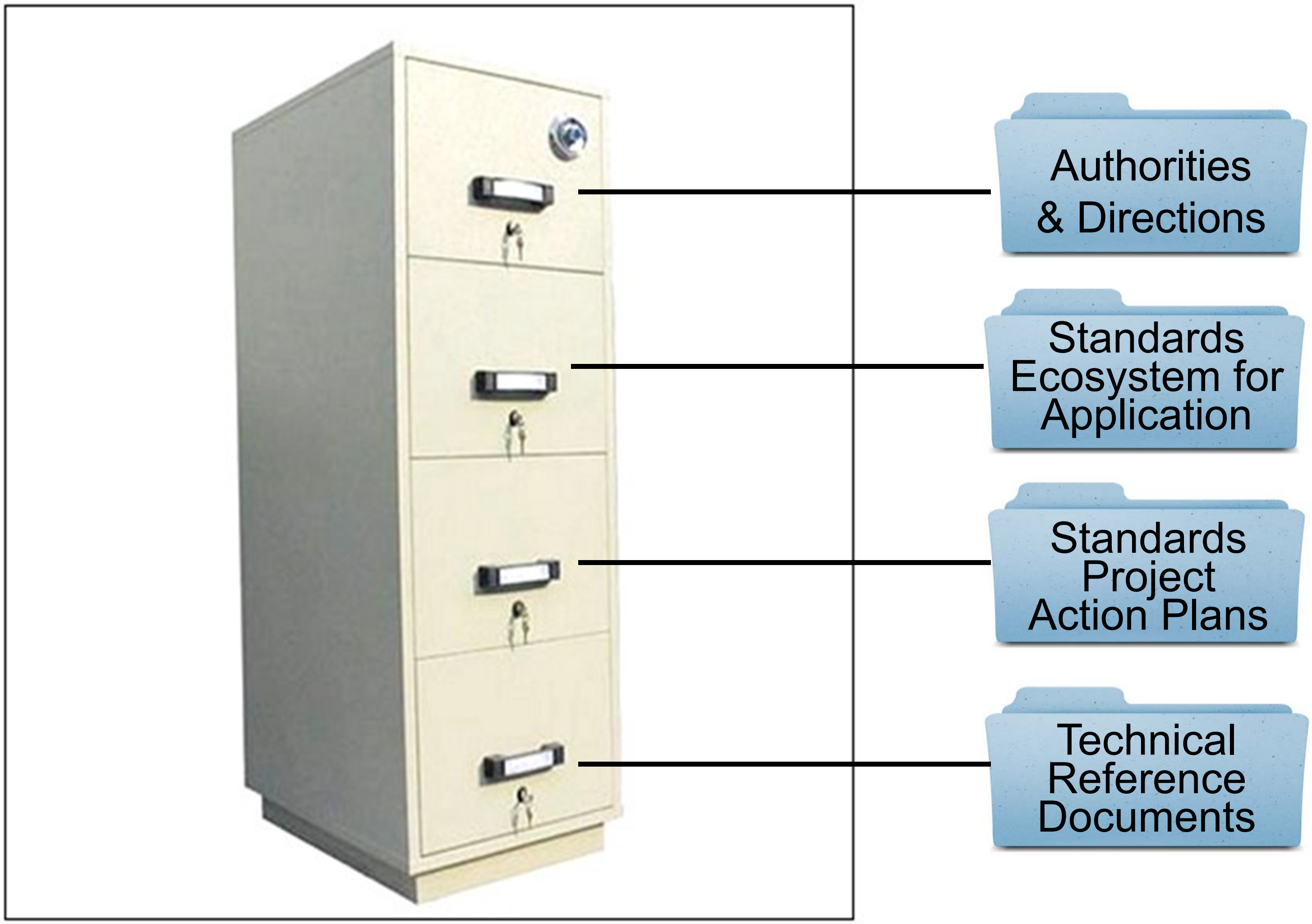
Context for Standards Application Platforms

- Eight consensus committees (CCs) cover standardization for the full range of nuclear technology applications
- RP3C is a resource and a guide to achieving the outcome objective of incorporating risk-informed and performance-based (RIPB) approaches into ANS standards
  - The functional mechanism for addressing the outcome objective exists within Working Groups (WGs)
  - WGs exercise a great deal of autonomy and can afford only limited time to absorb and execute new methodologies
  - It takes time to move from a prescriptive mind-set to one that is performance-based
- CCs and WGs work with a wide range of SDOs. Level of interaction between the CC silos can be improved
  - Assessing capabilities of existing standards in the context of a particular application can be difficult and time-consuming
  - Communication solutions became available only recently
  - Engaging new people is a particular challenge

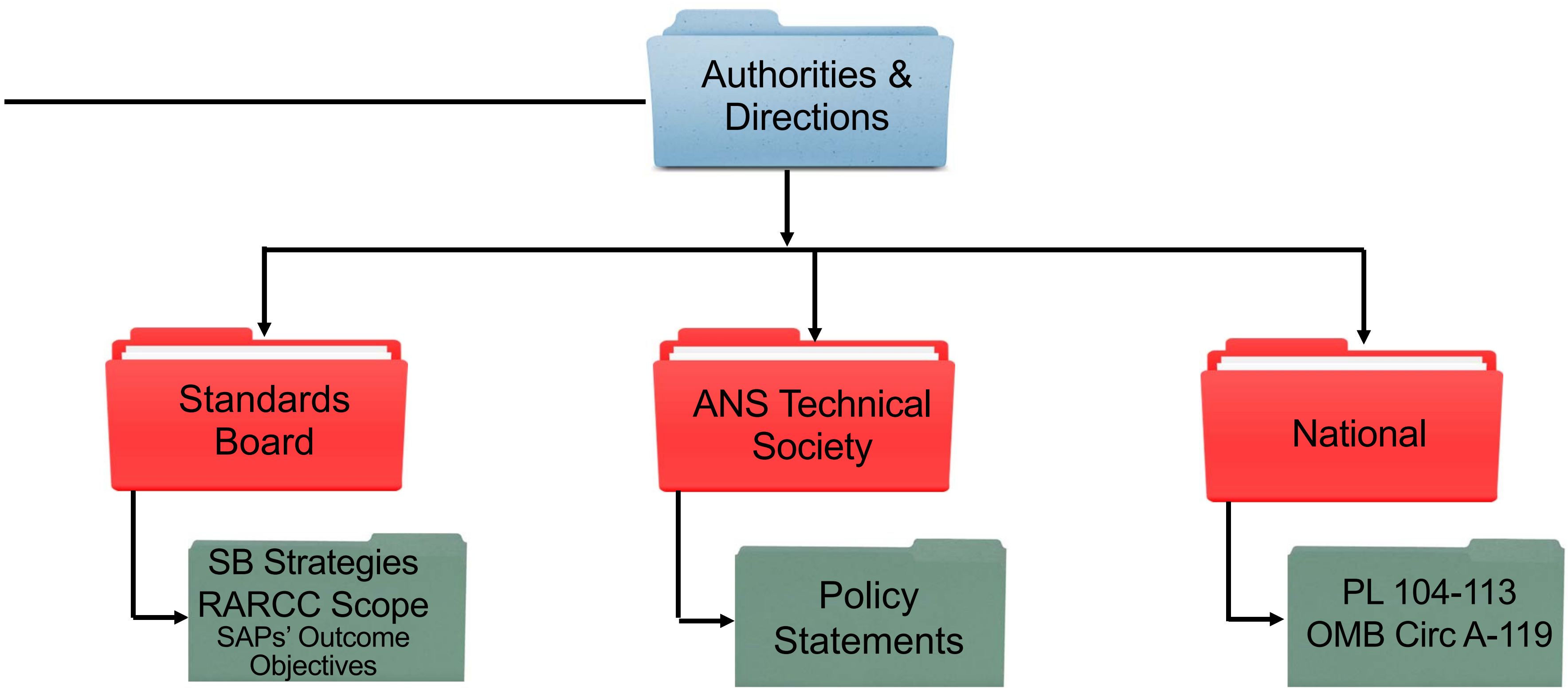
What are Standards Application Platforms (SAPs)

- SAPs are compilations of CC-centric information that promote integrated decision making
- SAPs are conceptualized as virtual cabinets with standards projects' knowledge management, organization and action plans
- The combination of existing and planned voluntary consensus standards supporting the outcome objectives constitutes the standards ecosystem
- Each CC develops and maintains its SAPs
  - CCs should include status reports in SB reports
- The totality of SAPs capture the extent of RIPB approaches for all ANS standards and constitutes the RP3C's on-going RIPB Plan

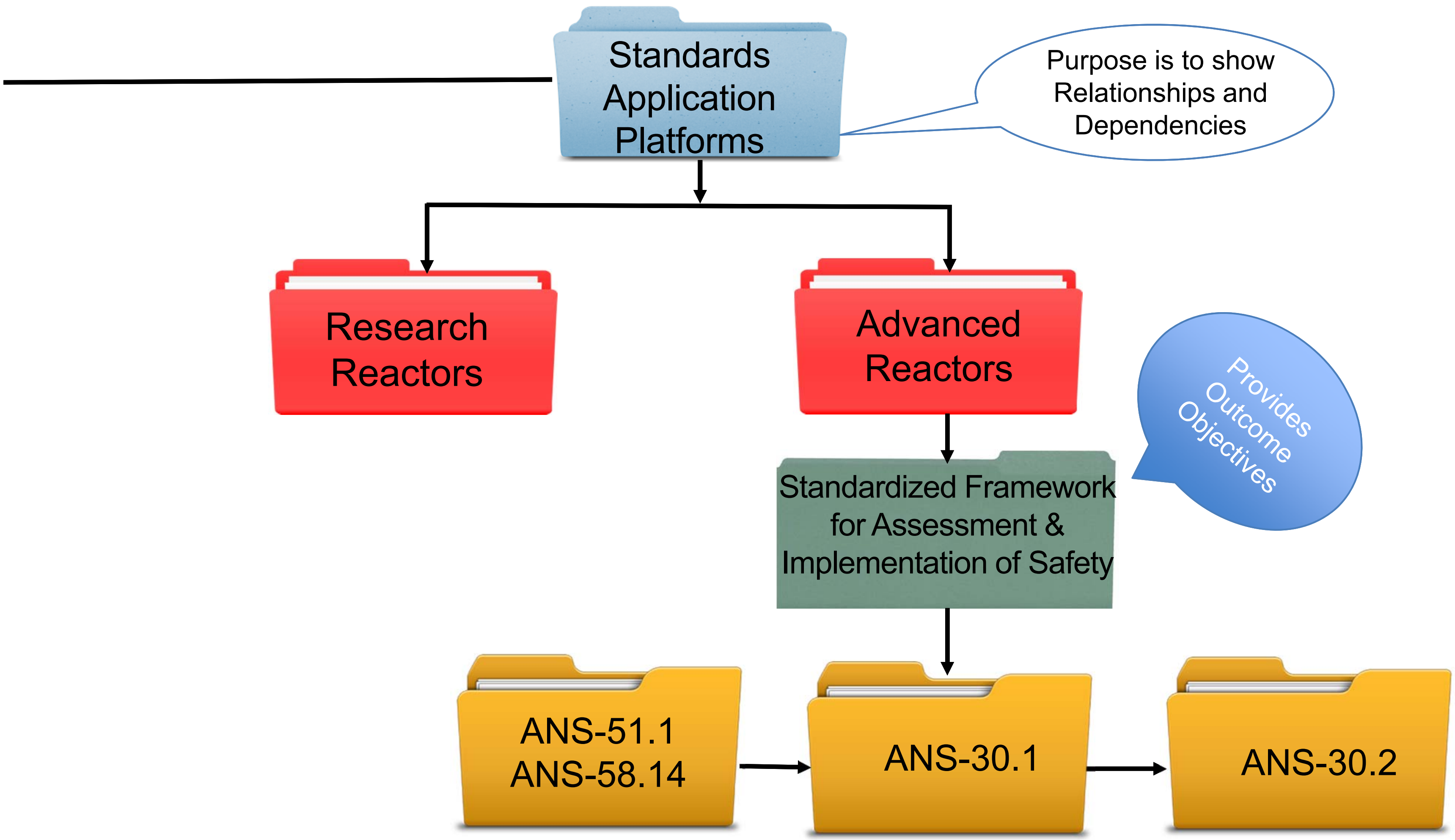
Example RIPB Standards Application Platform for RARCC



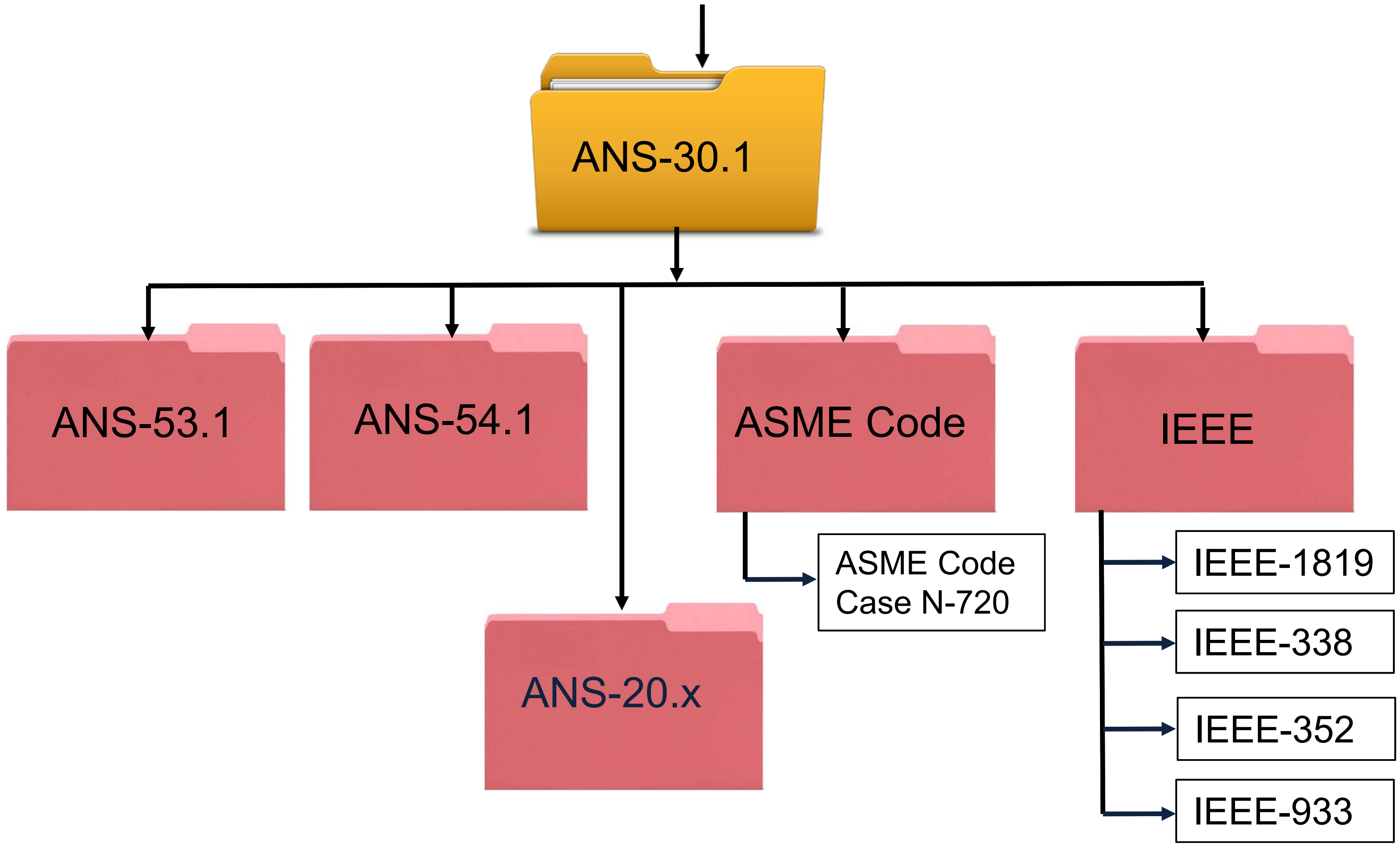
Example RIPB SAPs for RARCC(continued)



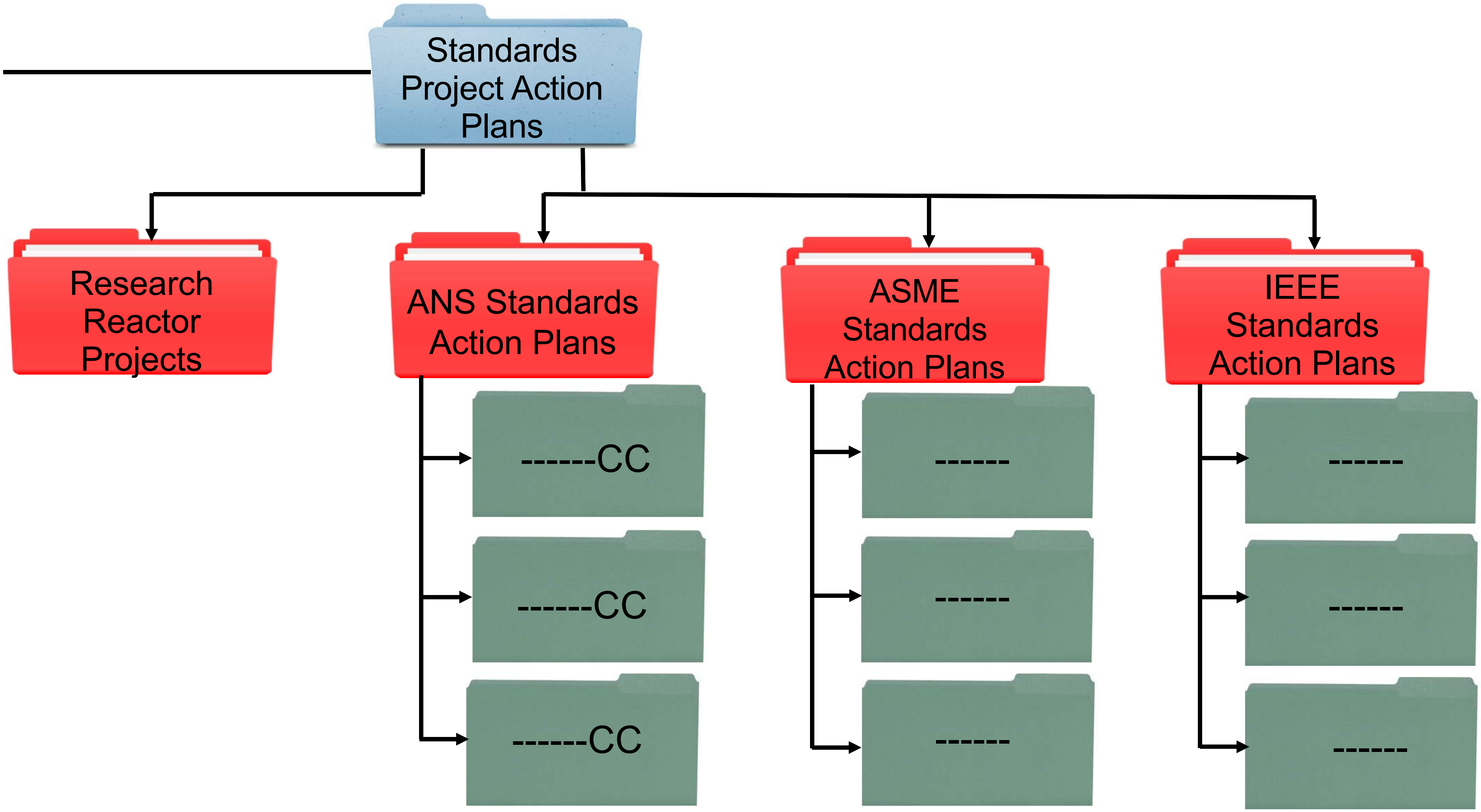
Example RIPB Standards Plan for RARCC



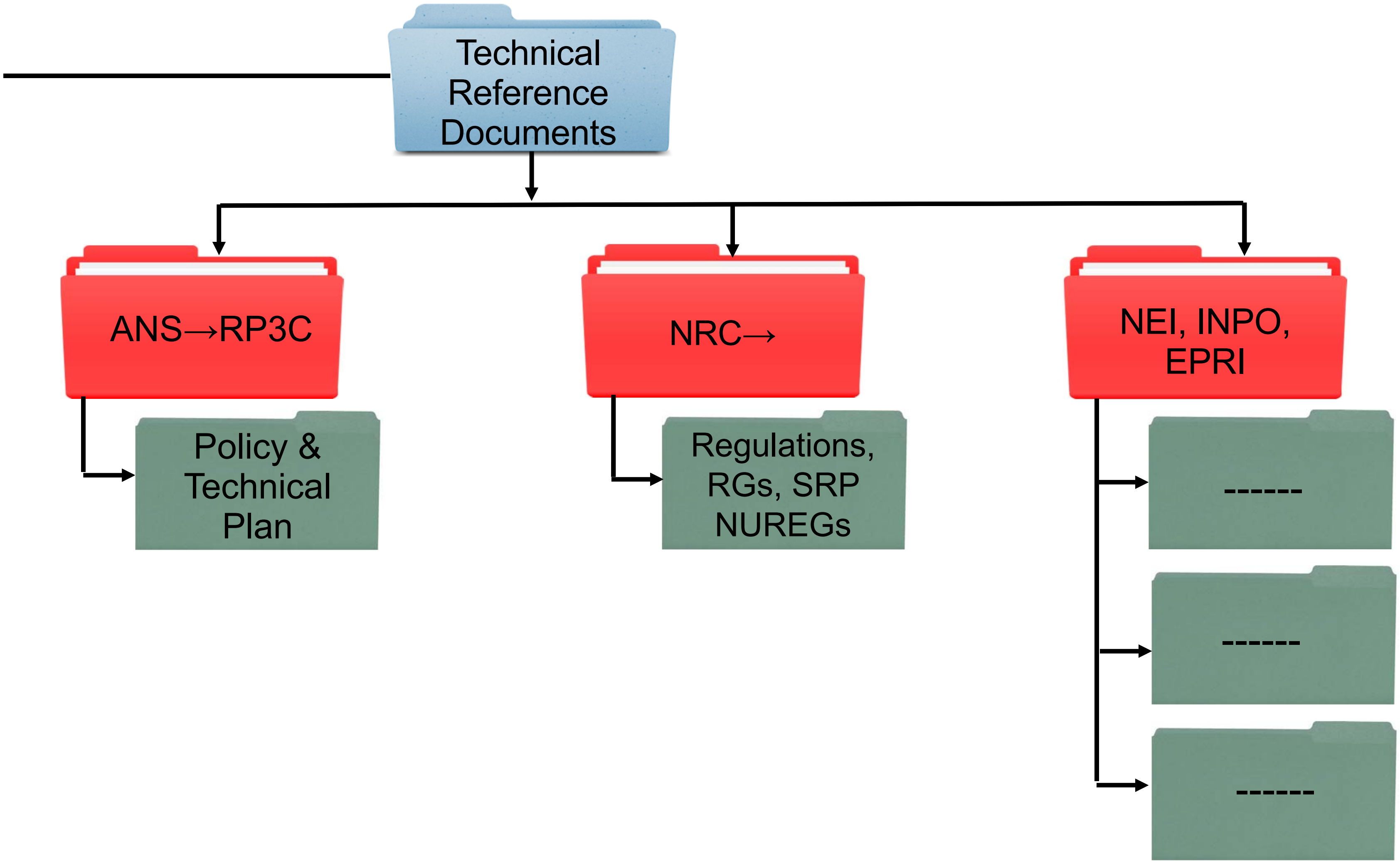
Example RIPB Standards Plan for ANS-30.1



Action Plans for Standards Projects Supporting Advanced Reactor Design Outcomes



Technical Reference Documents for RARCC SAPs



WG ANS-30.1 Queries

- Queries submitted in mid to late August, 2015
  - RP3C interaction limited by lack of time
  - Not feasible to get TG engaged
  - Intention to gain efficiencies from Workspace
- Response drafted to focus on technical issues
  - Technical background of RIPB literature needed
  - Technical focus offered opportunity to gain familiarity with relevant documents
- Safety policy choices elucidated by group discussions
  - Discussions should include RP3C members along with WG and CC members
  - Continuous process of feedback and clarification

WG ANS-30.1 Queries (continued)

- Categorization of scenarios
  - TG engagement with WG should produce options
- Deconstruction of CDF
  - "Gaming" is a non-issue
- Event cut-off frequencies
  - It does not appear that there is such a cut-off as a matter of practice
- RIPB methods for SFC application
  - An NRC report sent up to the Commission appears to be relevant
  - TG engagement with WG should produce options

Thoughts on “Standardization of BDB Evaluations”

Bob Youngblood

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)

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

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

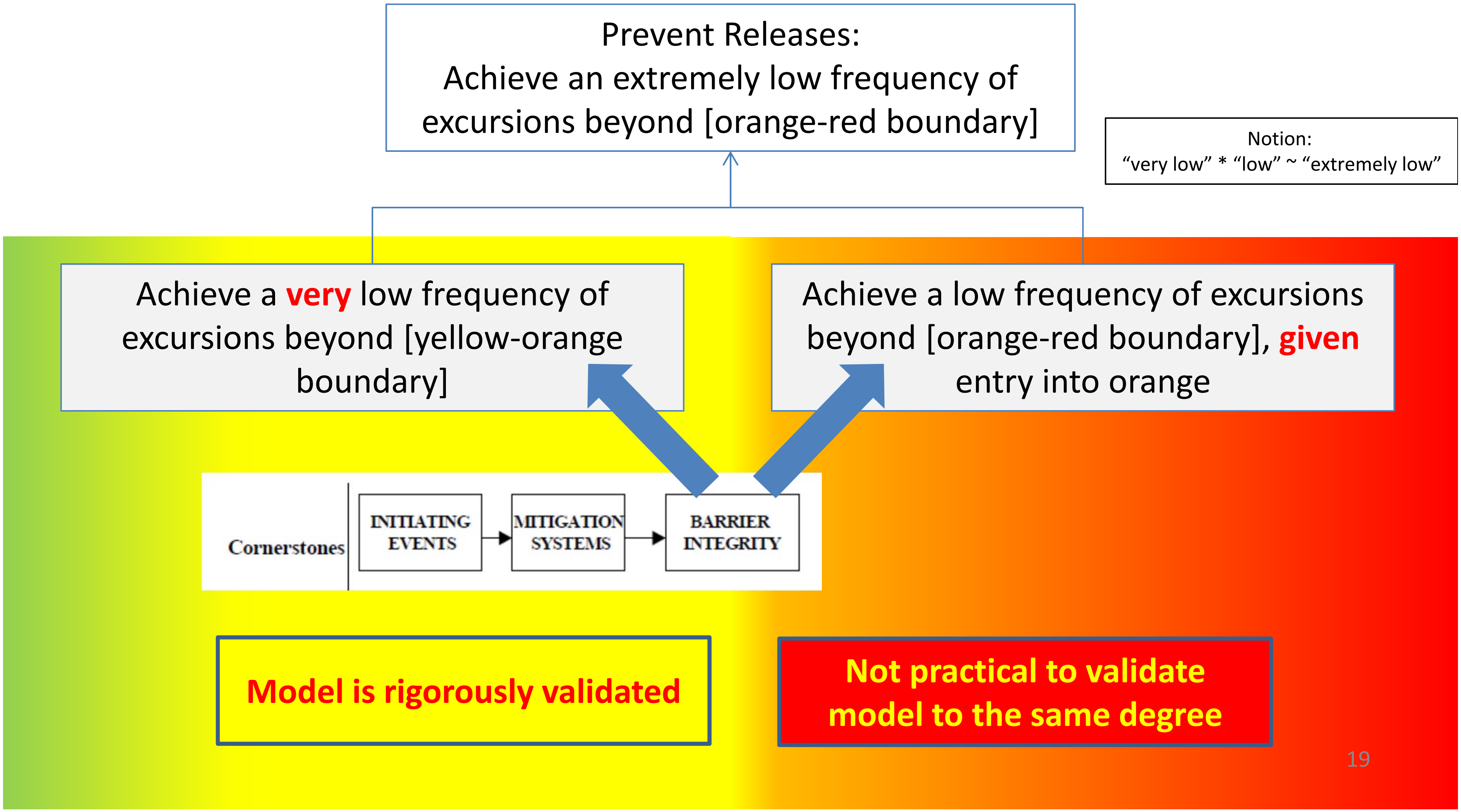
Standardization of BDB Evaluations (contd)

- 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

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

- Until we invent new phrases, this package will use "DB" and "BDB," to mean the following
  - 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



Increasing Severity →

Simulation Model is *Practical* to validate	Simulation Model gets *Harder* to validate
SSCs qualified for the environments that they see **AND**	SSCs **NOT** qualified for the environments that they see **OR**
Geometry intact: no breached barriers (only VERY minor leakage), no significant change in fuel geometry [for solid fuel types], … **AND**	Geometry **NOT** intact: breached barriers (> VERY minor leakage), significant change in fuel geometry [for solid fuel types], … **OR**
Only limited chemical reactions or changes in composition **AND**	Chemical reactions or changes in composition **OR**
No new phases **AND**	New phases **OR**
Simulation model is validatable at the system level **AND**	Simulation model is **NOT** validatable at the system level **OR**
Success paths can be shown to have margin: SSCs individually have margin to failure, capability > success requirement	Success paths can **NOT** be shown to have margin (not all SSCs individually have margin to failure; some may have failed)

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***

The point:

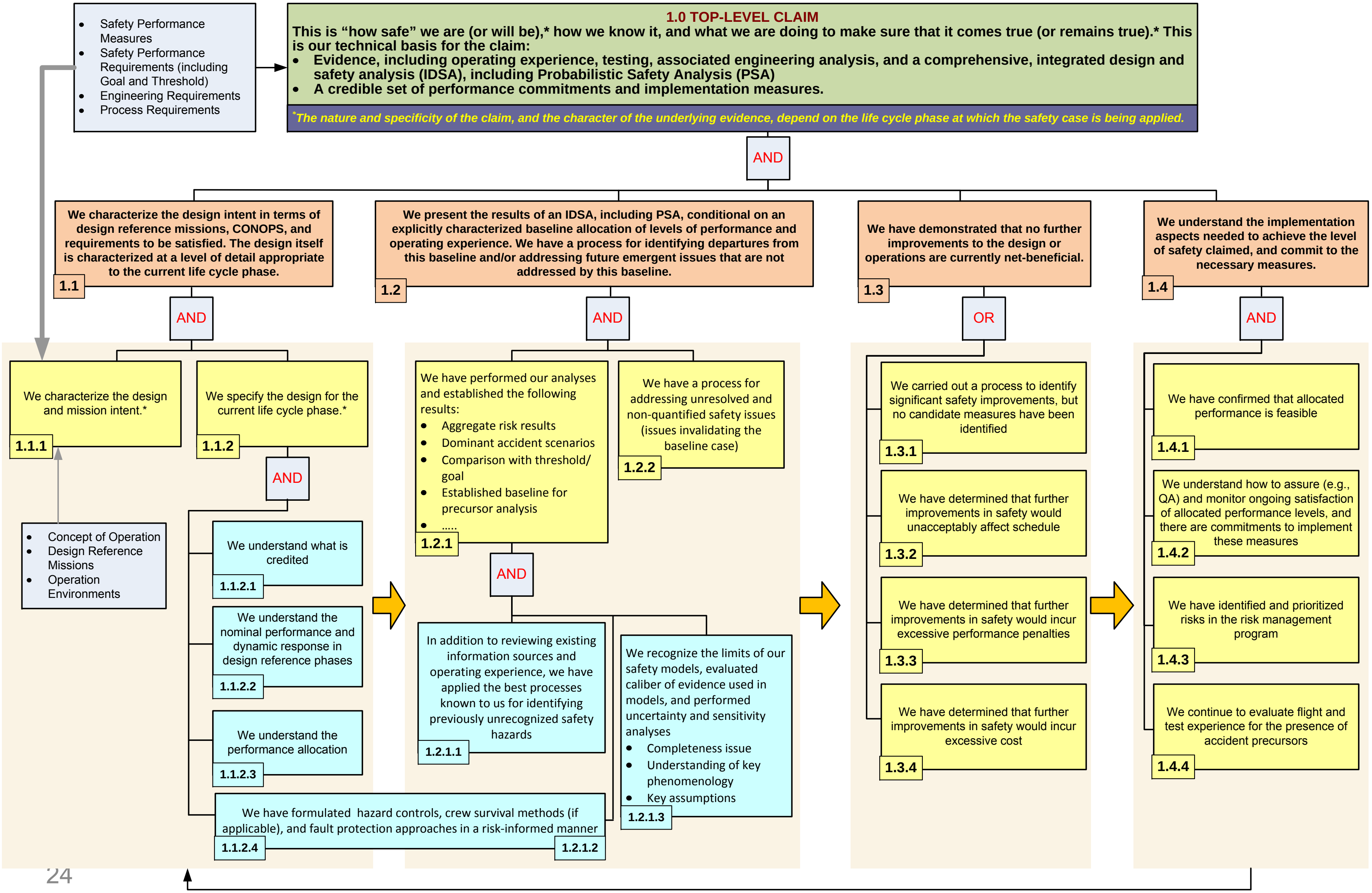
- The designer faces a refutable hypothesis:
  - we have a ***validated*** model within the DB region,
  - and therefore can argue ***convincingly*** that the frequency of leaving the DB envelope is very low.
- If we can't validate our model as far out as we'd like to, the problem faced may be one of hypothesis testing.
  - NUREG/CR-6833 offers methods to pursue such solutions
- For Gen II plants, this meant validating the plant T/H model, covering certain multiple-failure scenarios.
  - The T/H model of all the "OK" sequences in level 1 models would need to be validated, and it needs to yield a very low frequency of "not OK."
  - There needs to be significant margin and a very good treatment of epistemic uncertainty (including model uncertainty) (at least it's validated!).
- **Unfortunately, we still need to invoke a *process* argument to address completeness of the scenario set.**

Safety Case

- This approach is much closer to “safety-case” thinking than to any version of the classical prescriptive approach.
  - The applicant figures out how to establish certain fundamental attributes, and sells the demonstration to the regulator in the “case”
  - Comports well with “performance-based” thinking
  - This will need
    - Evidence (tests, prototype operation, …) of model validity
    - Process-based elements (completeness)

Generic Risk-Informed Safety Case Claim(s)

Source:
Work for NASA



Examples of What a Safety Case Needs for Present Purposes

- Protocols for reasoning about
  - the characters of the challenges (the entries into the orange box),
  - their very low frequencies, how to relate those frequencies to needed levels of assurance of functional performance in the orange box
- Protocols for dealing appropriately with the larger uncertainties
  - Expert Evidence / SSHAC?
- Some attention to the difficulty of performance-basing the case for features that are hard to test and never used

High-Level Table of Contents of the "BDB" portion of the safety case

These are the analog of "initiating events" in the DB portion of the case

I. Given Initial conditions
- Challenges to BDB functionality
  - The DB model provides us the event tree paths {scenarios, frequencies, physical attributes} of the scenarios that cross the DB -> BDB boundary
- Design information (Systems to be credited in analysis of BDB response)

II. Analyze plant response to each "challenge"
- I.e., develop {scenarios, frequencies, consequences (release magnitude, …)}
- Make the strongest possible ***process*** argument (show the strength of the hazard identification processes used to identify and analyze BDB phenomena, system failure modes, etc.), recognizing that the available models suffer more from uncertainty than the DB models
  - Acknowledge the potential for USQ's and allow for their possibility
- Analyze margin with great care (recognizing epistemic uncertainty, less-validated models)
- The hoped-for result: the conditional probability of release is ***low***
  - For individual challenges
  - And in the aggregate
- If you don't get the answer you want, go back and tweak something, quite possibly the plant response in the "DB" portion to reduce the frequency or the severity of the challenges to BDB functionality

III. Show design is "as safe as reasonably practicable"
- Necessarily a process argument at least in part (consider alternatives to design, …)

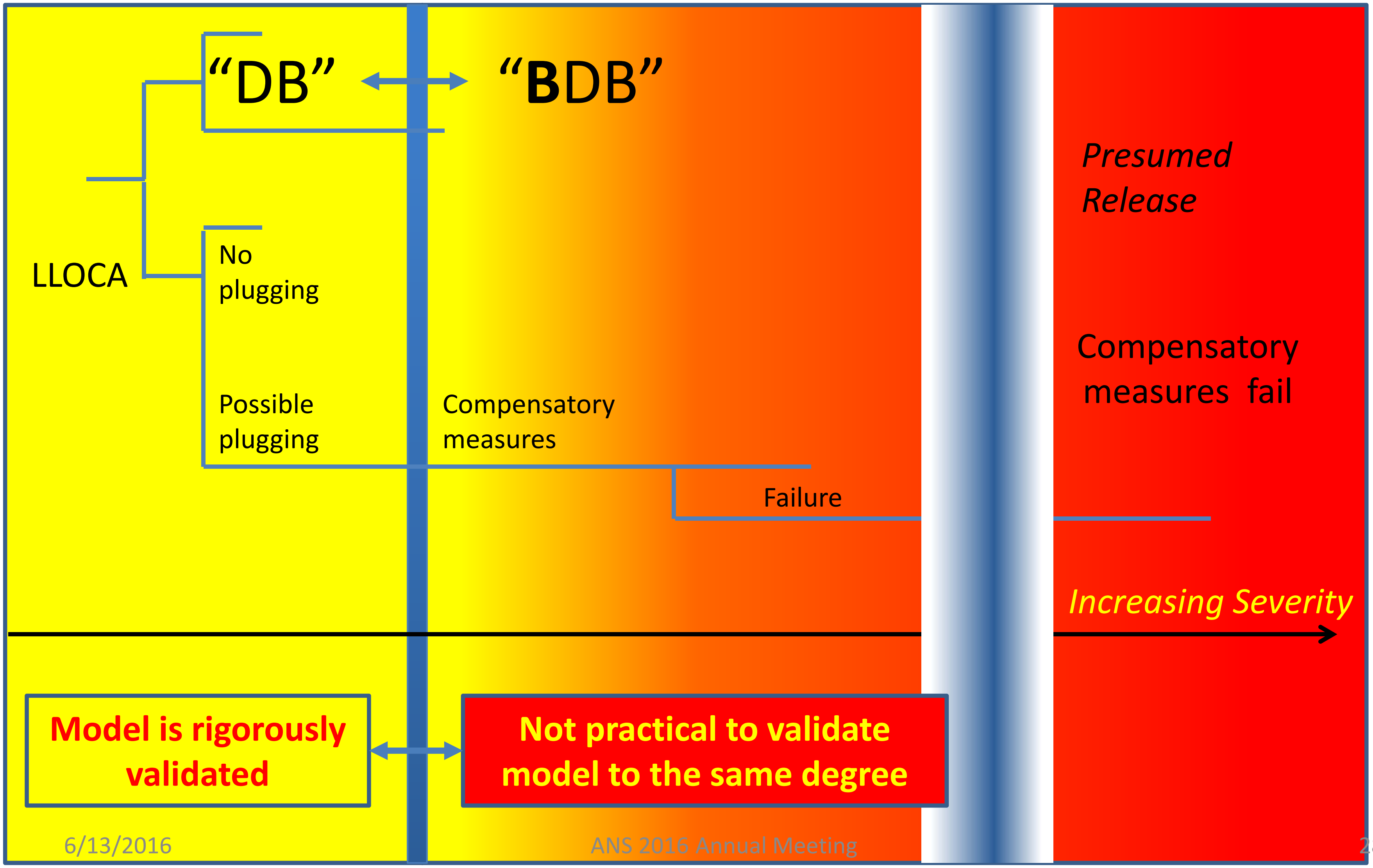
IV. Capture the implementation needs implied by credit taken for SSCs, including special treatment (QA, environmental qualification, testing, inspection, …)
- **Commit to fulfilling the implementation needs**
- **Identify ways to monitor performance on an ongoing basis**
- **Link special treatment to the credit taken in the analysis**

Special Treatment

- The foregoing approach culminates in an allocation of performance over SSCs, which then requires treatment. This is in the far right leg of the safety case chart.
- There would be more treatment for things that keep the plant in the yellow zone, less (but still some) for things that keep it in the orange zone.
- It seems to me that there are plenty of ideas on special treatment that could plug into the foregoing, if the foregoing made sense.

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



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

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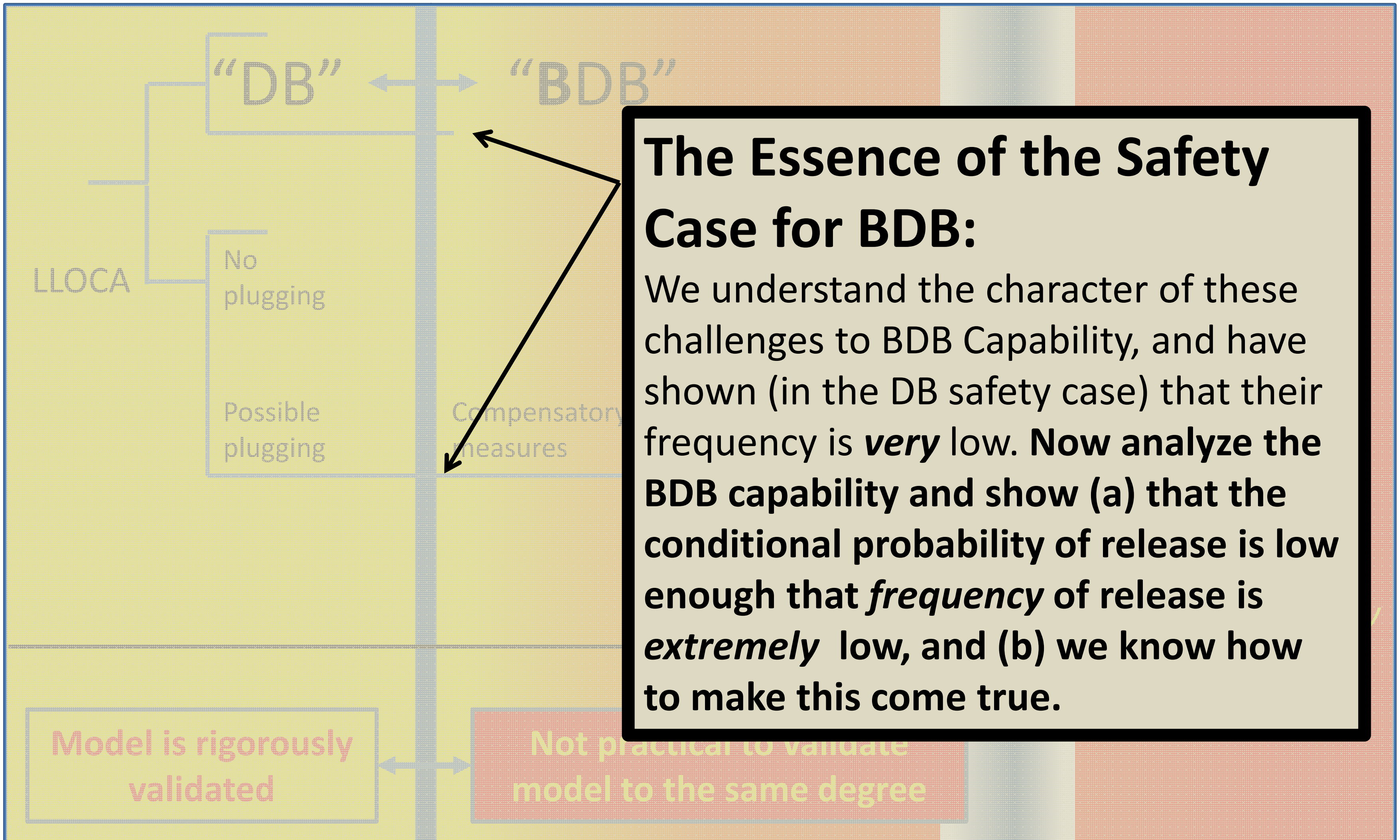


The Essence of the Safety Case for BDB:

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.**

Summary

- **Scope: the region currently known as "beyond design basis"**
- **The purpose is to figure out how to assure that "significant release" will be extremely rare**
  - **How to make it true**
  - **How to SHOW that it's true**

What "special treatment," … is needed?

- **The frequency of significant release will be extremely low if the *frequency* of entry into the orange region is very low, and the conditional probability of going from orange to red is low. ("quite low" * "low" ~ "extremely low")**
- **Expect that at a high level, a generic "safety case" outline will more or less work, but we need protocols that address what's special about the orange region: increased epistemic uncertainty, difficulty of validation, …**
- **Assuming that major elements of the foregoing can make sense, we need to think up better names for yellow, orange, and red**

Clip from SRM to SECY 10-113

Using a no-transition-break-size approach, staff can **assess whether debris fouling can be treated as a beyond design basis event**. This approach would allow for the practical assessment of plant design features and operator actions (including human reliability evaluation) that could not only reduce the likelihood of sump clogging (e.g., strainer backwashing) but also reduce plant dependence on sump recirculation for long-term cooling through better water management (e.g., refill of the refueling water storage tank (RWST), cross tie to another RWST, and manual operation of containment spray). Furthermore, under this approach, existing plant-specific B.5.b equipment, which is already captured in each plant's licensing basis, could be credited1 to mitigate the potential consequences of sump-clogging scenarios. As an element of this assessment, the staff should consider licensee PRA information, if available, that assesses the full spectrum of pipe break sizes, plant-specific compensatory measures, and design features that could reduce sump clogging risk. The Commission was recently informed that one such study is being planned by a licensee2.

Evolving Advanced Reactor Design Guidance

- A deliberative process has taken place within RP3C since the last meeting as a result of which emergence of a framework to help designers of advanced reactors appears likely
- The deliberative process also reveals embedded principles and policies that promote achievement of desirable outcome objectives

Lessons from Gen II

- The idea of validation has been used in an open ended way such that there is regulatory opportunity to unnecessarily ratchet up level of validation.
- If the designer uses the safety case approach effectively, the arguments in favor of a graded approach to validation would be constructed with risk-informed regulatory practices in mind.
- NUREG/CR-6833 describes the Receiver Operating Characteristics approach to hypothesis testing whereby the likelihood is estimated of being on the wrong side of a decision threshold criterion.
- If Gen II designs had constructed issue spaces optimally, there would be less argument about validation of models (and hence, technical adequacy of PRAs) than now.
- The controversies regarding the adequacy of defense-in-depth are related to ineffective construction of arguments in favor of safety margins arising from redundancy, diversity and independence within the safety case (such as it is).
- Difficulties with adopting 10 CFR 50.69 suggest that there may be a better way to implement a graded approach to safety

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)"

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

Changing Environment

- NRC and the Risk Management Regulatory Framework proposed in NUREG-2150
  - SRM to SECY-2015-0168
  - No policy level documents regarding risk management
  - No “design extension category”
  - Silent on future reactor application of risk management methods
- NRC-NEI Risk Informed Steering Committee
  - RISC meetings in February and May 2016
  - Wrapping up task groups on PRA uncertainty and technical adequacy
  - Greater focus on FLEX
  - Mention of concern regarding aggregation

RP3C Interfaces

- Interface with ANS Standards Board
  - RP3C will report progress toward execution activities
  - Need governance help in promoting engagement with CC on RIPB standards
- Interface with JCNRM
  - Need clarity on obtaining PRA methodological help
  - Need clarity on roles and responsibilities of SCoRA vis-à-vis RP3C
  - NRMCC has been disbanded
- ANS Public Policy Committee
  - Draft policy statement on RIPB has been offered
  - Task Group has been set up and is at work

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

- **Other Business**
- **Next Meetings**
  - ANS Winter Meeting, November 6-10, 2016, New Orleans, LA
  - ANS Annual Meeting, June 11-15, 2017, San Francisco, CA

- **Adjourn and Thank You!**

BACKUP

BACKUP

&

BACKGROUND

SLIDES

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

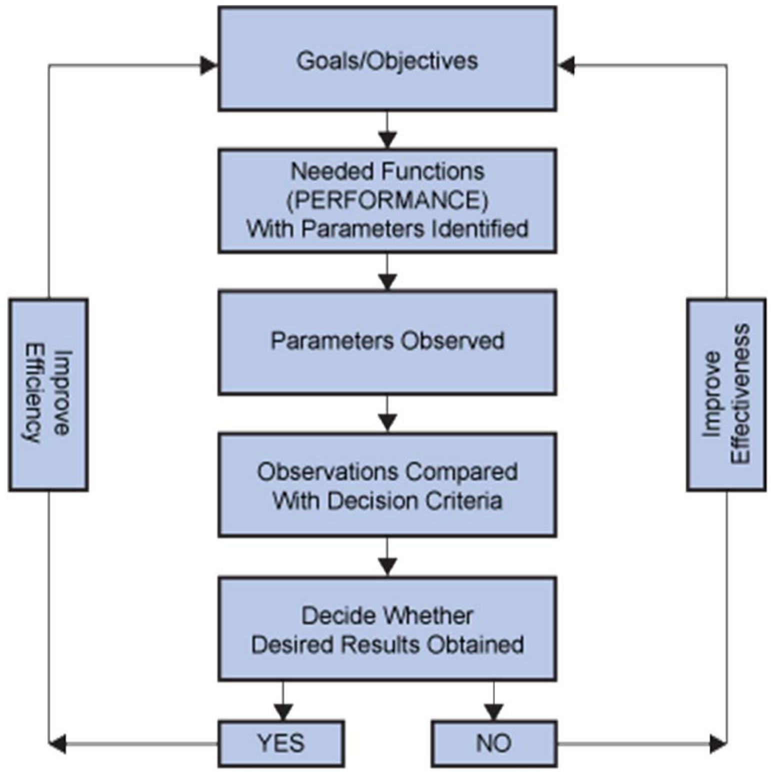
Principles	Policies
• Licensed activities must be conducted with "no undue risk"	• Assure low probability of accidents that can adversely affect health and safety
• Experience with operational facilities shows "no undue risk" criteria met with deterministic approach that considers safety margins, uncertainties 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.

Risk Regimes Grid for Performance Standards

Table 3 of Draft RP3C Plan:

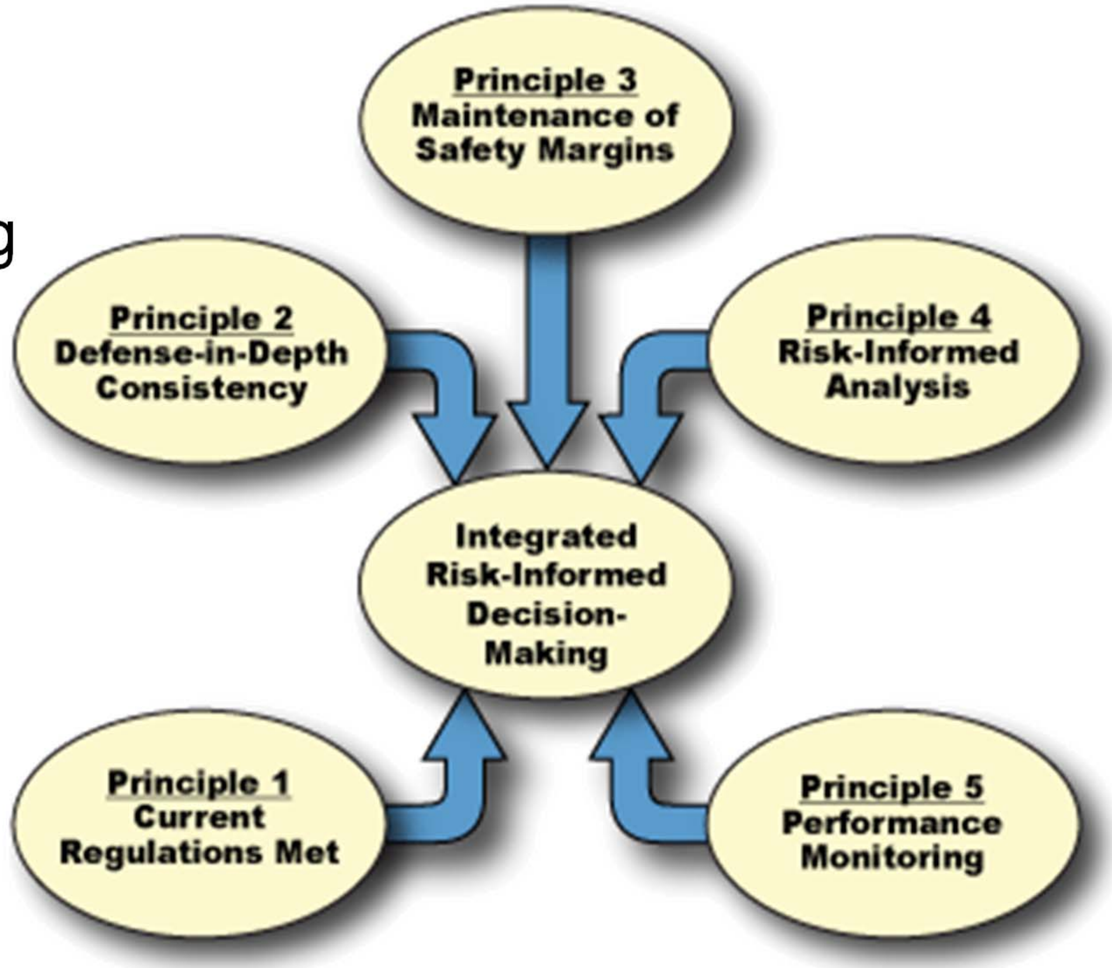
	RISK REGIME	PROCESS STANDARDS	PERFORMANCE STANDARDS	
		Process Elements, Structure, Sequence & Acceptance Criteria	Specify Challenge	Specify Capacity
DETERMINISTIC	Acceptable Performance With Single Failure Criterion Applied	Process Elements Based on 10 CFR 50, App A DBA Structure Stylized Event Sequence Conservative Acceptance Criteria	Low Probability-Maximized Challenge to Primary Fission Product Barrier Low Probability (DB) External Events	Bounding Low Capability of Primary Fission Product Barrier
FREQUENCY BASED	Acceptable Performance Without Application of Single Failure Criterion	Event Tree – Fault Tree Analysis DBA Structure with functional redundancy Mechanistic Sequences Quantitative/Qualitative Acceptance Criteria	Low Probability-Maximized Challenge to Primary Fission Product Barrier Lower Probability (BDB) External Events	Best Estimate Capability of Primary Fission Product Barrier Criteria for Functional Success
LEVEL 1 PRA	Acceptable Performance With Acceptable Risk of Primary FP Barrier Failure	Top Event is Primary FP Barrier Failure Mechanistic Sequences Quantitative/Qualitative Acceptance Criteria	Initiating Event Sequences with Human Errors Mechanistic Source Term	Best Estimate Capability of Primary Fission Product Barrier Operator Performance Functional Success Including FLEX
LEVEL 2 + 3 PRA	Tolerable Risk Based on Containment Failure Frequency + Emergency Procedures Implementation	Level 2 or Level 3 PRA Mechanistic Sequences Quantitative/Qualitative Acceptance Criteria	Lowest Probability Combination Events (eg. Multi-Module Events)	Best Estimate Capability of Containment Function Operator Performance Including EOP Implementation

Steps for Performance-Based Approach Implementation



RIPB Decision Framework

- Source: RG 1.174
- Basis for binning
- Can a change impact licensing basis?



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Schedule of ANS Standards in Development using RIPB Properties (June 2016)

Standards Project	Draft App'd by WG	+4 months SubC or Preliminary Review/Comment Resolutions	+6 months 1st CC Ballot/Comment Resolutions (concurrent PR)	+4 months 2nd CC Ballot/Comment Resolutions (concurrent PR)	+2 weeks ANS Standards Board Certification	+2 Weeks ANSI Approval	~4 months Publication
ANS-2.8 (Y. Gao) / *Environmental & Siting CC (C. Mazzola) Determine External Flood Hazards for Nuclear Facilities JCNRM Rep: V. Anderson, D. Finnicum, R. Schneider		Incomplete draft issued to the ESCC for prelminary review in late 2015.	No update provided.				
ANS-3.8.7 (R. Markovich) / *LLWRCC (G. Carpenter) Properties of Planning, Development, Conduct, and Evaluation of Drills and Exercises for Emergency Preparedness at Nuclear Facilities JCNRM Rep:			On hold until DOE reviews draft.				
ANS-3.13 (J. August) / *LLWRCC (G. Carpenter) Nuclear Facility Reliability Assurance Program (RAP) Development JCNRM Rep:	No update provided.						
ANS-20.1 (E. Blandford) / *RARCC (G. Flanagan) Nuclear Safety Design Criteria for Fluoride Salt-Cooled High-Temperature NPPs JCNRM Rep: R. Bari, R. Budnitz	No update provided.						
ANS-30.1 (M. Linn) / *RARCC (G. Flanagan) Risk-Informed & Performance-Based NPP Design Process JCNRM Rep: D. Johnson	No update provided.						
ANS-30.2 (D. Spellman) / *RARCC (G. Flanagan) Classification of SSCs for New Nuclear Power Plants JCNRM Rep: R. Grantom			PINS in approval stage.				
ANS-54.1 (G. Flanagan) / *RARCC (G. Flanagan) Nuclear Safety Criteria & Design Process for Liquid-Sodium-Cooled NPPs *RARCC (G. Flanagan) JCNRM Rep: R. Budnitz	Draft on hold until NRC documentation on the sodium fast reactor design criteria has been completed; NRC expects publication by the end of 2016.						
ANS-57.2 (R. Browder) / *FWDCC (D. Eggett) Design Requirements for LWR Spent Fuel Storage Facilities at NPPs ANS-57.3 (R. Browder) / *FWDCC (D. Eggett) Design Requirements for New Fuel Storage Facilities at LWRs JCNRM Rep:	No update provided.						
ANS-57.11 (B. Eble) / *NRNFCC (J. O'Brien) ISAs for Nonreactor Nuclear Facilities JCNRM Rep:	No update provided.	Draft issued to NRNFCC for preliminary review in November 2015; significant comments received.					

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*= ANS responsible consensus committee

FWDCC = Fuel, Waste, & Decommissioning Consensus Committee
LLWRCC = Large Light Water Reactor Consensus Committee
NRNFCC = Nonreactor Nuclear Facilities Consensus Committee
RARCC = Research and Advanced Reactors Consensus Committee