

Safety Margin in RIPB Methods

N. Prasad Kadambi

Retired, USNRC Staff

Chair, ANS Risk-informed, Performance-
based Principles and Policy Committee

Outline

- ▶ Regulatory Structure Supporting Use of Safety Margins in RIPB methods
- ▶ Common Language and Technical understanding of Safety Margins
- ▶ NRC Initiatives that Advanced Better Understanding of Safety in Relation to Safety Margins
- ▶ NUREG/BR-0303, “Guidance for Performance-Based Regulation”
- ▶ Relevance to ANS Standards

RIPB Community of Practice Presentation of April 30, 2021

50.34(a)(4) A preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety resulting from operation of the facility and **including determination of the margins of safety** during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents...

Regulation More Suited for RIPB Methods

- ▶ 50.34(a)(2) A summary description and discussion of the facility, with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations
 - ▶ 10 CFR 50.34 has a hierarchical structure, and so 10 CFR 50.34(a)(2) has higher precedence than 10 CFR 50.34(a)(4)
 - ▶ Application should address design and operating characteristics even though current practice separates them
 - ▶ “Principal safety considerations” can be seen as a “safety case” that has a higher priority than “Principal design criteria” which appears in 10 CFR 50.34(a)(3)(i)
 - ▶ “Principal safety considerations” is more amenable to a performance-based approach as described in NUREG/BR-0303, “Guidance for Performance-Based Regulation”

Setting Performance Expectations is Important to RIPB Methods

- ▶ **Application Addresses Key Regulatory Expectations**
 - ▶ *Analysis and evaluation of design*
 - ▶ Analysis includes functional analysis that includes design and operational phases
 - ▶ Evaluation includes modeling and simulation
 - ▶ *Performance with the objective of assessing risk from operation*
 - ▶ Design and operation are considered in a continuum
 - ▶ *Determine margins of safety*

Common Language Understandings

- ▶ **Profit margins**

- ▶ Sale price minus cost of manufacture

- ▶ **Speed limits**

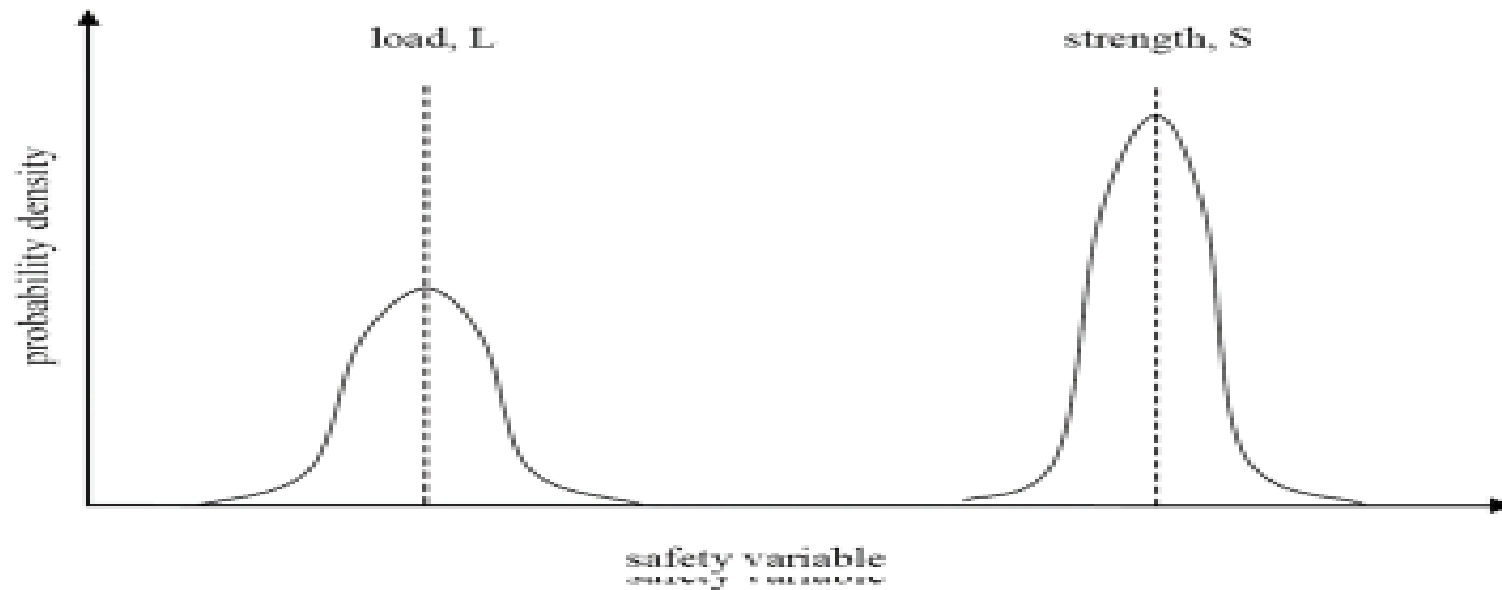
- ▶ Posted at 55 mph
- ▶ Enforced at 65 mph

- ▶ **Strict Compliance versus Conformance to Performance Objective**

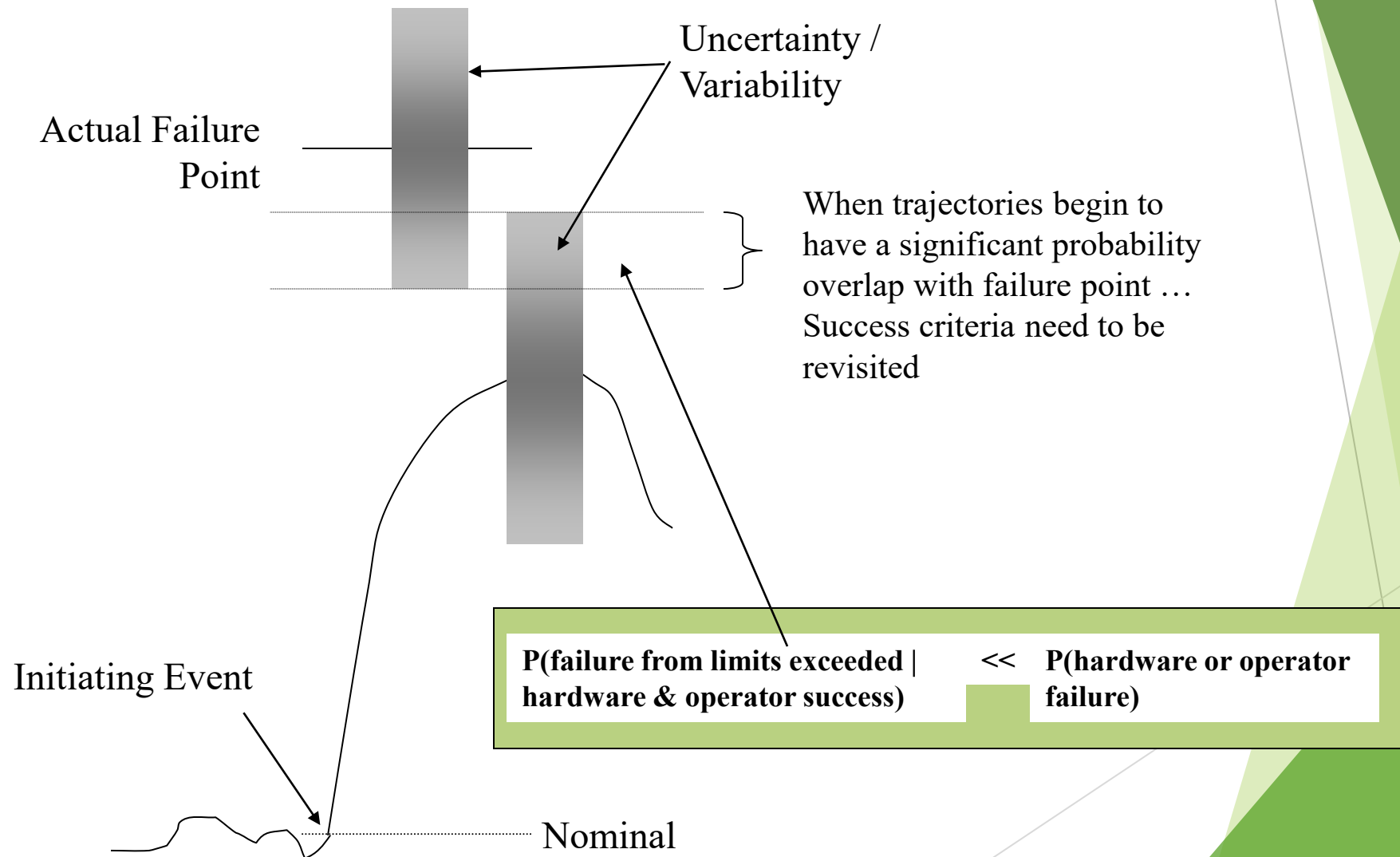
- ▶ Need for performance-based safety arises from perverse incentives of compliance
- ▶ Much more difficult to incorporate conformity assessment in ANS standards

Technical Understanding of Safety Margins

Concept of Safety Margin

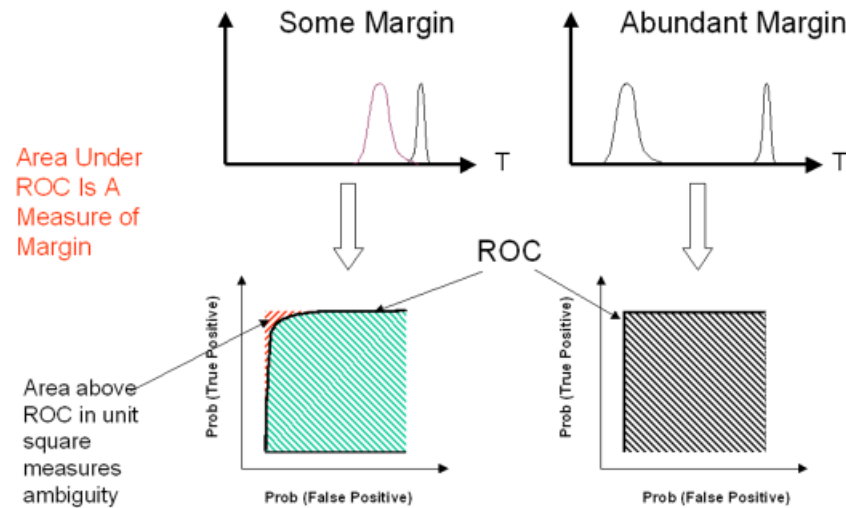


Margins as Applied to Reactor Transients



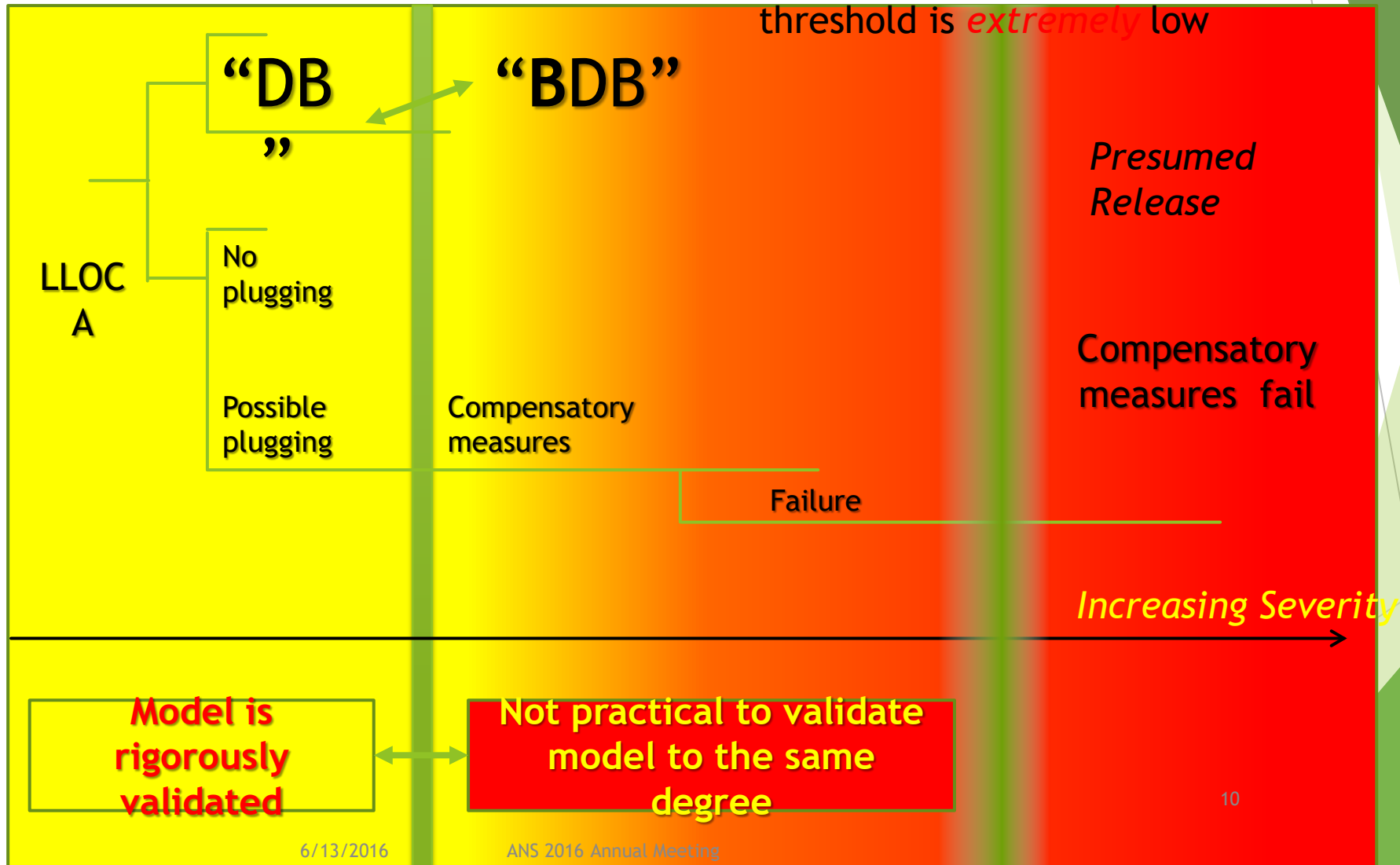
Technical Understanding of Safety Margins (Cont'd)

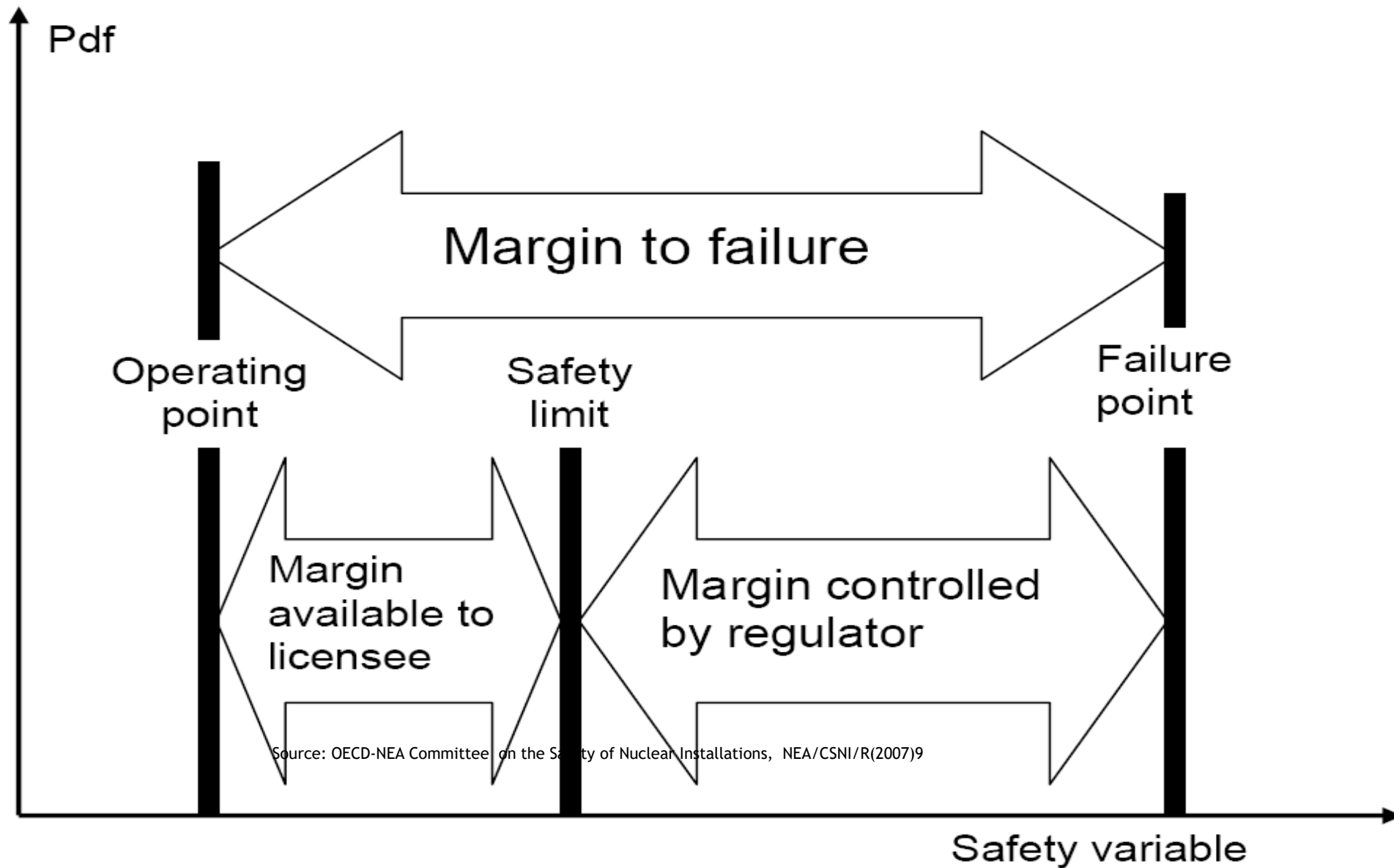
Section 4 – Performance-Based Regulation ROC Description of Margin



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

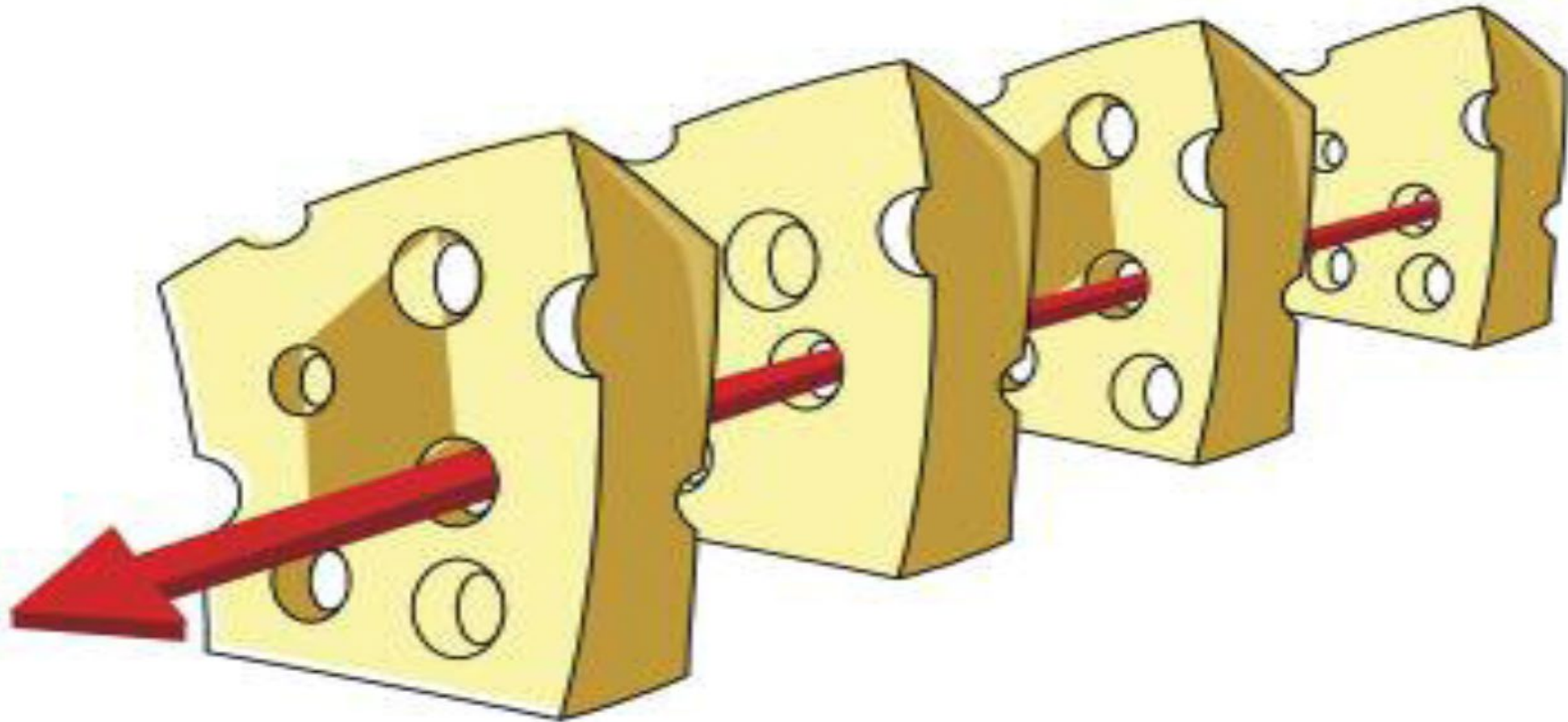
Argue that the *conditional probability* of crossing this threshold is “low,” and therefore the *frequency* of crossing this threshold is *extremely* low





Source: OECD-NEA Committee on the Safety of Nuclear Installations, NEA/CSNI/R(2007)9

Defense in Depth



NRC Commission-Level Initiatives to Change Regulatory Paradigm

- ▶ Commission re-examined the existing regulatory paradigm in the late 1990s under “Strategic Assessment and Rebaselining”
- ▶ Direction Setting Issue-12 on RIPB resulted in Commission direction (COMSECY-96-061)
- ▶ Should include SRM-SECY-96-218 and other activity
- ▶ Led to issuance of “White Paper on RIPB” (SRM-SECY-98-0144)
- ▶ Advanced non-LWRs can make a fresh start with 10 CFR 52 as providing the framework for licensing
 - ▶ Apply 10 CFR 50 technical requirements selectively
- ▶ 10 CFR 50.69 is partial realization of DSI-12
 - ▶ Make it performance-based so special treatment **actually matters**

SRM-SECY-98-0144

“White Paper On RIPB Regulation”

- ▶ “White Paper” is central to a formal basis for Commission’s initiatives for regulatory reform in 1999 which are especially valid for non-LWRs
- ▶ NRC staff has not sought to formally fulfill Commission’s expectations
- ▶ NUREG/BR-0303 sought to formally fulfill Commission’s expectations on performance-based safety
- ▶ Products from formal implementation NUREG/BR-0303 could enable an applicant to assert conformity with Commission expectations
- ▶ This is the basis for the formal application of NUREG/BR-0303 to American Nuclear Society’s standards program
- ▶ Industry does not appear to find value in formal application of “White Paper” definitions.

“White Paper” As Basis for Performance-Based Safety

- ▶ White Paper identifies four formal attributes of success in implementing a performance-based approach:
 - ▶ Measurable parameters
 - ▶ Decision criteria associated with the parameters
 - ▶ Licensee flexibility (with incentives for improved outcomes + monitoring)
 - ▶ Framework for margin requirements (physical and temporal)
- ▶ NUREG/BR-0303 formally set out to achieve Commission’s expectations from the “White Paper” for all NRC activities (reactors, materials, waste)
- ▶ Given the wide variety of activities involving radiation, radioactive materials, and fissionable materials, NUREG/BR-0303 was set up for two levels of application:
 - ▶ Simple scenarios
 - ▶ Complex scenarios

Success ⇔ Risk-informed, Performance-based Safety

- ▶ **Accomplish what actually matters**
 - ▶ RI ⇔ graded using risk information ⇔ most to least
 - ▶ PB ⇔ provides sound basis for showing that desired performance objectives are achieved
- ▶ **RIPB improvements and benefits demonstrated in Reactor Oversight Process**
- ▶ Unnecessary regulatory burdens are a feature of the prescriptive approach
 - ▶ Perverse incentives could be revealed by appropriate monitoring
 - ▶ Optimization of system responses can be confirmed by focusing on outcomes
 - ▶ Inspections and tests may be made to more directly support safety objectives

Desired Outcomes of NUREG/BR-0303

- ▶ The decision-making framework from NUREG/BR-0303 envisions development of alternatives with selection based on optimization
 - ▶ Prescriptive Vs. Performance-Based (More Margin => Less Prescriptive)
 - ▶ Deterministic Vs. Risk-Informed (Magnitude of and Confidence in Margin)
- ▶ Transparent assessment of costs and benefits
 - ▶ Structured objectives are more suited for life-cycle costs and systems engineering approach to design, operation and decommissioning
- ▶ Realize the benefits from the flexibility afforded by the US regulatory framework
 - ▶ NRC staff only recently seems to have become motivated toward PB
- ▶ Realize the outcomes from Yellow Announcement COMSAJ-97-008, “Discussion on Safety and Compliance”

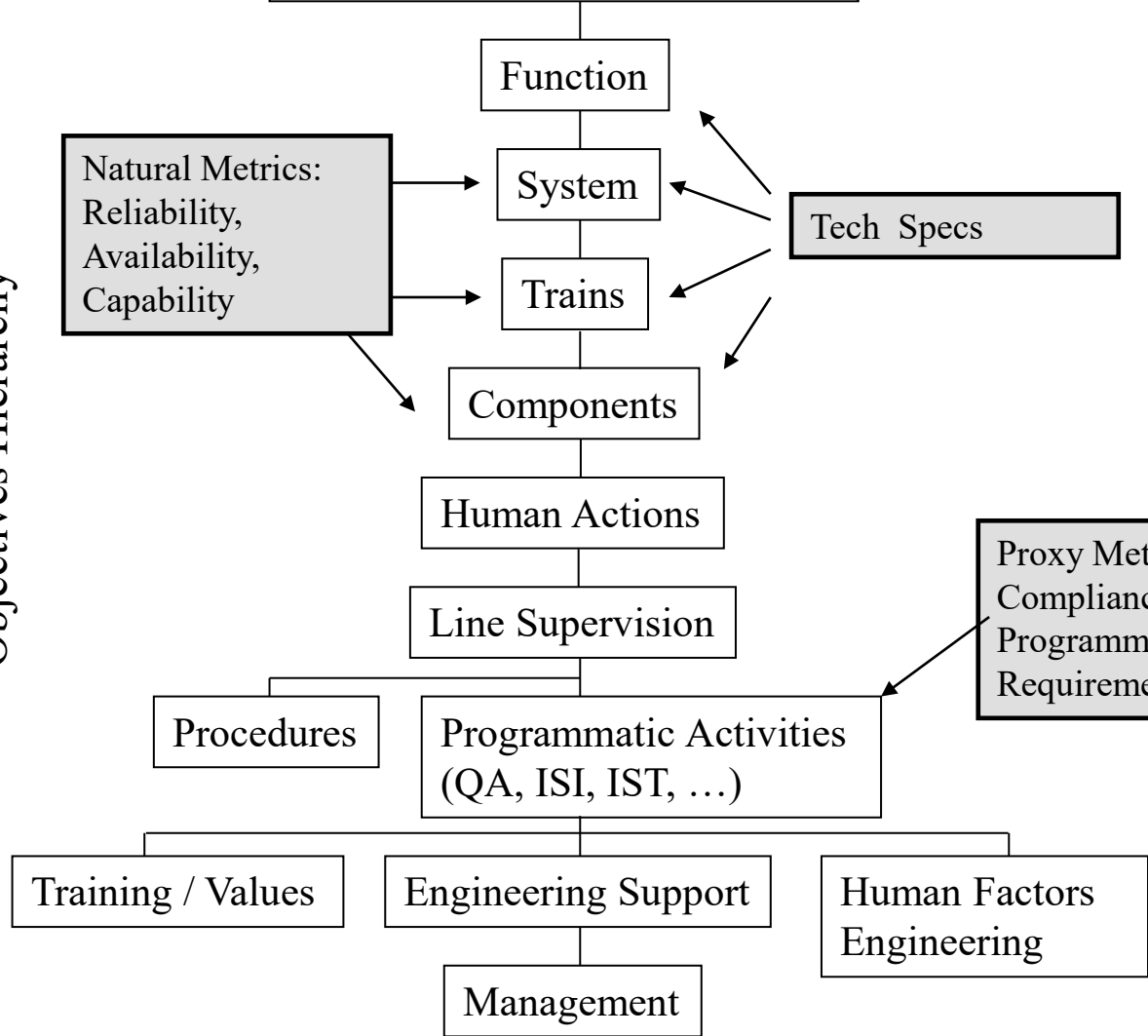
Means Objectives Hierarchy

Performance Goal

Cornerstone Level

Mitigating Systems Performance

Objectives Hierarchy



More Prescriptive

More Performance-Based

State-of-Play for NUREG/BR-0303 With Its Derivatives

- ▶ The performance-based decision-making framework of NUREG/BR-0303 was supported by two other documents:
 - ▶ Elements of an Approach to Performance-Based Regulatory Oversight. NUREG/CR-5392
 - ▶ Formal Methods of Decision Analysis Applied to Prioritization of Research and Other Topics, NUREG/CR-6833.
- ▶ The Licensing Modernization Project produced the following document that is being used for ANS standards:
 - ▶ “Introduction to Implementation and Assessment of Safety for Risk-Informed and Performance-Based Technical Requirements in Non-Light Water Reactors,” Draft Report (Rev. 1), U.S. Department of Energy, Idaho Operations Office, Contract DE-AC07-05ID14517
- ▶ NUREG/BR-0303 is being referenced in ANS and ASME standards
- ▶ NUREG/BR-0303 is the only guidance so far for performance-based approaches in the Part 53 rulemaking

RIPB Safety Margins in ANS Standards

- ▶ The RP3C RIPB Guidance Document is focused on helping ANS standards to reduce unnecessary prescriptive elements
 - ▶ Distinguish outcomes from outputs so that margins available from a structured set of performance objectives can be used to reduce costs.
- ▶ ANS presentations at the NRC's Standards Forum on October 13, 2020 emphasized realistic assessment of margins for harmonization of standards
 - ▶ Assess margins provided by a set of standards providing acceptable margins for design and operation considered holistically
- ▶ ANS standards currently under development or revision look to RP3C for recommendations for modernization
 - ▶ ANS-30.1, 30.2 and 30.3 are key to demonstrating value of considering safety margins on a systems engineering framework.

Summary

- ▶ Formal consideration of safety margins is well suited for meeting Commission's expectations of regulatory reform
- ▶ 10 CFR Part 50.34 provides a hierarchical construct for developing a safety case for any reactor, resulting in "...determination of margins of safety during normal operations and transient conditions..."
- ▶ Incorporating defense-in-depth in a technology-inclusive manner appears inevitably linked to employing a performance-based approach modelled along the lines of NUREG/BR-0303
- ▶ Considering that NUREG/BR-0303 is the only NRC approved document that treats safety margins formally in nuclear technology at this time, it is important to see how much benefit the guidance may offer a nuclear licensing application