RIPB Design and Licensing Lessons Learned

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Outline

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- NuScale implementation for design certification application/US600
- Lessons learned
- Summary and conclusions

Definitions

- **Risk-informed (ANS 30.3).** Process whereby risk insights are considered together with deterministic analysis that
  a) allows explicit consideration of a broad set of potential challenges to safety,
  b) provides a logical means for prioritizing these challenges based on risk significance, operating experience, and/or engineering judgment,
  c) facilitates consideration of a broader set of resources to defend against these challenges,
  d) explicitly identifies and quantifies sources of uncertainty in the analysis (although such analyses do not necessarily reflect all important sources of uncertainty), and
  e) leads to better decision-making by providing a means to test the sensitivity of the results to key assumptions. Risk-informed approaches lie between the risk-based and purely deterministic approaches.

Definitions

- **Performance-based (ANS 30.3).** An approach to design or regulation that relies upon the desired, measurable results or performance outcomes based on objective criteria rather than a prescriptive process, technique, or procedure. Performance-based regulation differs from a traditional, prescriptive regulatory approach by emphasizing what is to be achieved rather than how desired results and outcomes are obtained.

- **Defense-in-depth (ANS 30.3).** The concepts of providing programmatic controls and plant capability with multiple layers of defense to radionuclide release, successive measures to prevent an accident or mitigate the consequences of an accident, and the use of redundancy and diversity to accomplish risk-significant safety functions.

Key concept – risk-informed framework

Traditional "Deterministic" Approach

- Unquantified probabilities
- Design-basis accidents
- Defense in depth and safety margins
- Can impose unnecessary regulatory burden
- Incomplete

Risk-Informed Approach

- Combination of traditional and risk-based approaches through a deliberative process

Risk-Based Approach

- Quantified probabilities
- Thousands of accident sequences
- Realistic
- Incomplete

Balance between deterministic and probabilistic approaches.

Background

- Several pre-application meetings were held with the NRC to discuss RIPB concepts and agree upon an approach for design certification application (DCA)
- Risk Significance Determination Topical Report developed TR-0515-13952-NP-A
- NuScale subsequently developed a risk-informed design and licensing approach for the US600 baseline and submitted a DCA
- During the DCA review, numerous topics incorporated RIPB approaches and were discussed with the NRC and ACRS
- Lessons learned from the DCA review effort can help to support current and future RIPB initiatives

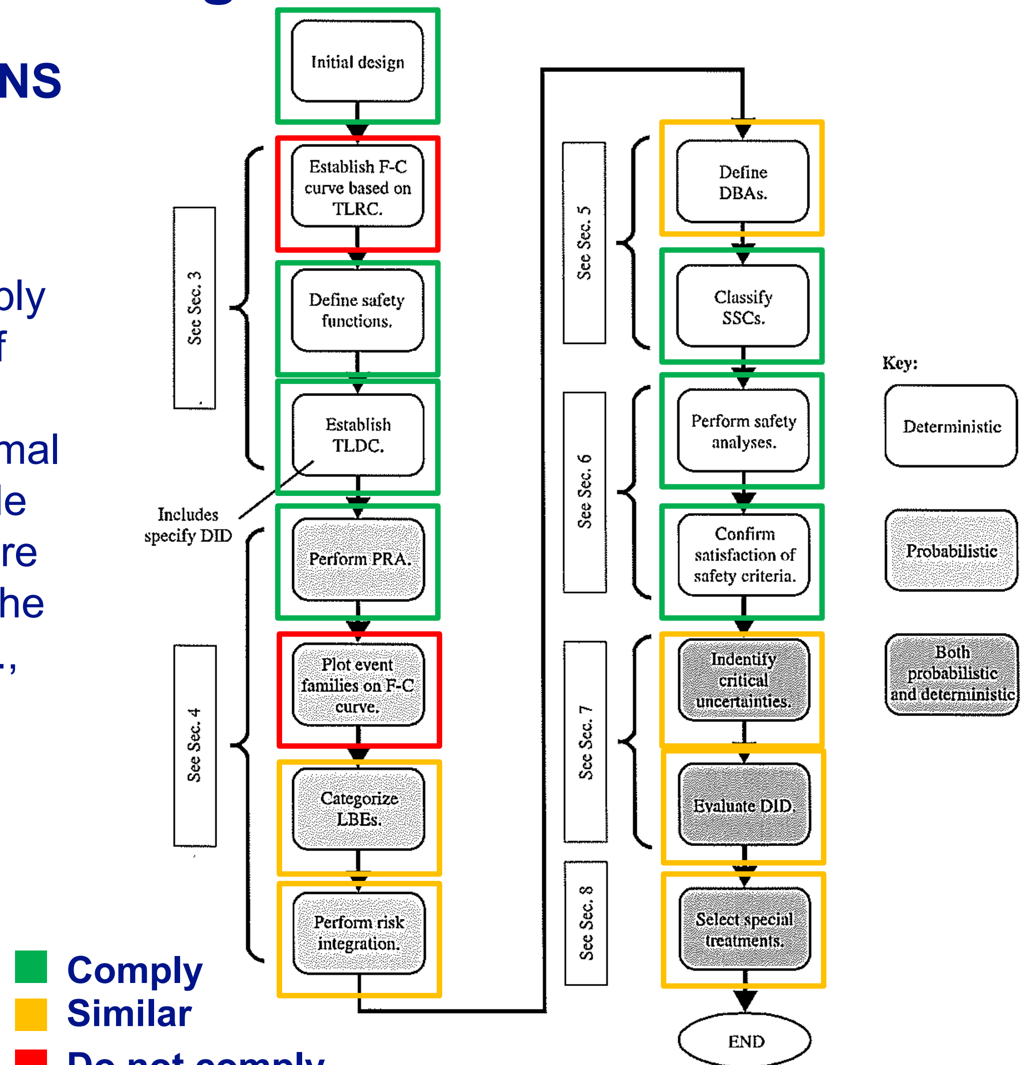
NuScale DCA Pre-App meeting on RIPB methods

- In July 2012, NuScale provided an overview of unique plant features that provide low risk to public safety and ensure adequate defense in depth (DID)
- Provided NuScale views on RIPB design and licensing approach
- Presented NuScale approach to fundamental RIPB licensing elements, including
  - use of PRA to inform NuScale selection of licensing basis events
  - SSCs safety classification
  - DID adequacy framework
- NuScale presented an older version of the DID framework from ANS 53.1, Gas Reactor Design Standard (which was the predecessor to NEI 18-04, Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development)
- Obtained NRC feedback on proposed design-specific review standard (DSRS) Chapter 19 requirements, including interfaces to other chapters
  - *Based on this feedback, NuScale ultimately decided to take a more traditional approach for risk-informing and not implement the approach described in ANS 53.1.*

NuScale DCA Pre-App meeting on RIPB methods

- **NuScale approach versus ANS 53.1 process**
  - no use of F-C curves
  - no structured DID
  - many process elements comply or are similar in intent, even if the methods are different
  - overall, ANS 53.1 is more formal and rigorous, but less valuable for LWRs as compared to more advanced designs for which the standard was developed (e.g., gas reactors)

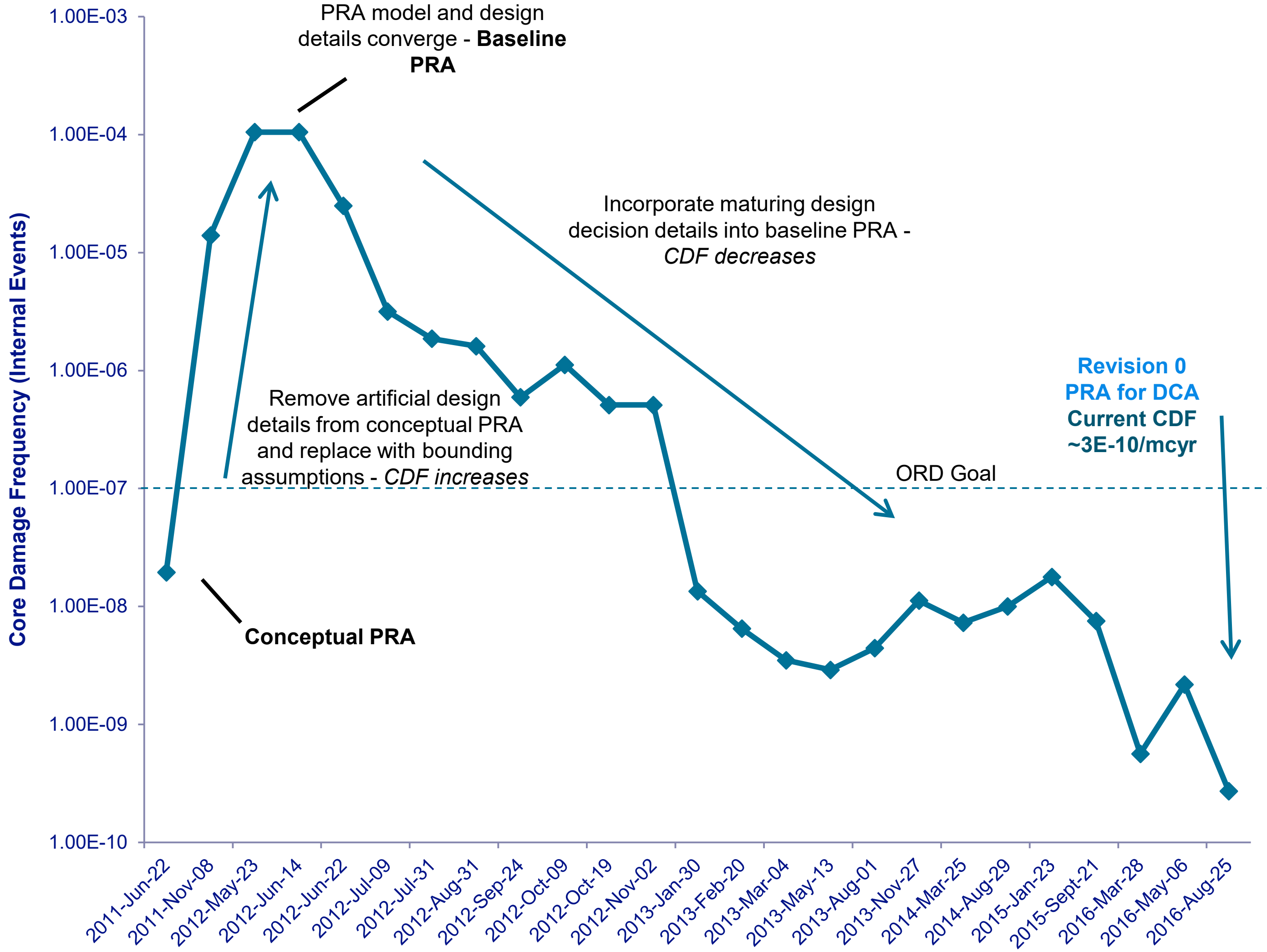
DBA = Design basis accidents
DID = Defense in depth
F-C = Frequency-consequence
LBE = Licensing basis event
SSC = Systems, structures, and components
TLDC = Top-level design criteria
TLRC = Top-level regulatory criteria



NuScale RIPB Implementation for US600/NPM160

- Risk-informed performance goals via Owners Requirements Document (ORD)
  - Primarily CDF (<1E-7), site boundary EPZ, and passive safety
- PRA was used extensively to risk-inform the design
- Risk evaluations were conducted to support design alternatives, as requested
- PRA key safety insights were summarized in DCA Chapter 19
  - Ultimate heat sink is co-located with reactor modules and protected by engineered, Seismic Class-1 structure
    - not susceptible to environmental hazards or disruptions in heat transfer systems
    - under conservative, bounding conditions will last many months
  - Relevant safety systems consist of about a dozen fail-safe valves
    - heat transfer to UHS completely passive
  - Small core size and self-limiting nature of heat transfer processes enhance reliability for maintaining core cooling

Historical Change in CDF Estimate (US600/NPM160)



NuScale risk-informed decision making process

- PRA is kept up to date to support risk-informed decisions
- Every engineering change request is evaluated for risk impacts
- PRA membership on engineering change board and D-RAP panel
- Additional risk evaluations are conducted to support design alternatives as requested

DCA/US600 lessons learned

- No agreed upon credibility threshold (within the industry and NRC) for risk importance measures (e.g., CDF, LRF) drives design decision to be more deterministic (e.g., expensive) to reduce regulatory risk
- Identification and quantification of risk uncertainty is VERY important to the regulator and ACRS
  - reliability data for unique components (e.g., ECCS valves) routinely questioned and challenged
  - symptomatic of a low risk profile, very small values for CDF and LRF
- Acceptance of RIPB approaches can change based on NRC reviewer
- Have overcome numerous design and operational challenges using risk-informed performance-based approaches

Summary and conclusions

- RIPB principles and methods are well developed in the United States
- NuScale has a well established PRA team and demonstrated practice of risk-informing plant baselines
- NuScale has had mixed success applying risk-informed principles in the U.S. licensing process due to lack of consensus in some key areas such as credibility threshold for events and how to address uncertainties in the PRA at the design stage
- More work is needed both by industry and the regulator to support broader use of RIPB methods in the design and licensing processes