ANS 30.3 and Performance-Based Decision Making

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Outline

- Terms and definitions
- Background
- Performance-based decision making
- NuScale implementation
- Conclusions and summary

Terms and definitions

- **Performance-based.** 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. (ANS Glossary)

Background

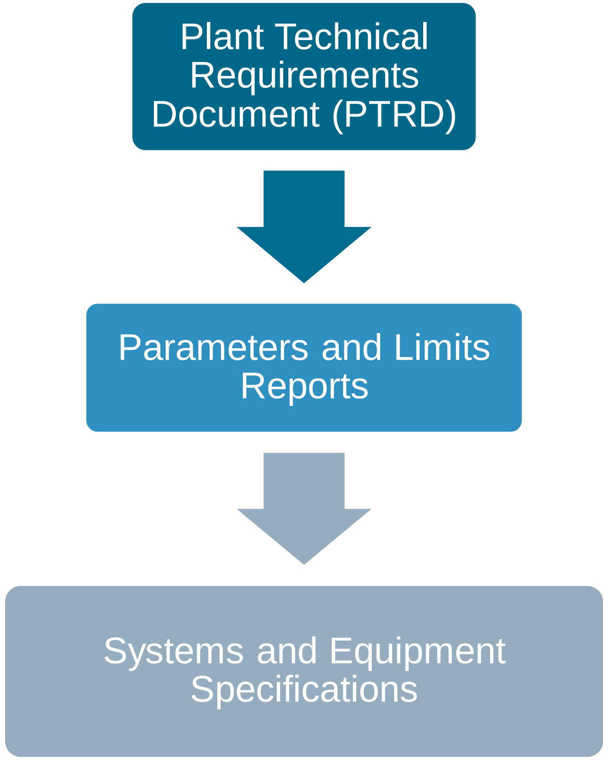
- Since 2018, NuScale has been supporting the development of ANS 30.3, "Advanced LWR Risk-Informed Performance-Based Design"
- ANS 30.3 went for ballot June 2021 with about 100 comments received.
  - Previous to balloting, 200+ public review comments were addressed and a revision provided
- A revision to ANS 30.3 was completed October 2021 to address ballot comments and sent back for consensus committee review
- ANS 30.3 contents:
  - Nuclear reactor design process
  - Safety requirements and functions
  - Licensing-basis event identification
  - Design-basis safety analysis
  - Probabilistic risk assessment
  - Classification and categorization of structures, systems, and components (SSCs)
  - Systematic defense-in-depth (DID)
  - ***Performance-based decision making***

Performance-based decision making (ANS 30.3)

- Performance-based safety objectives shall be used to support decision-making related to design and evaluation of plant systems and components.
- The decision-making process during nuclear power plant design development shall be formal and evidence-based in order to allow for explicit treatment and consideration of risk insights into the design.
- The decision making process shall also incorporate decision analysis that evaluates decisions against specific performance-based safety goals.
- The performance-based decision analysis process shall have the following characteristics:
  - objective criteria to assess performance based on risk insights, deterministic analyses, and/or performance history
  - quantitative and qualitative RIPB decision criteria to support transparent and repeatable decisions; NUREG/BR-0303 describes how qualitative and quantitative criteria should be developed and used for decision making
  - recognition of different levels and types of DID when considering alternatives, including evaluation of safety margins evaluation of tradeoffs on plant capital and operation cost versus risk reduction
  - adequate treatment of uncertainties in the PRA results and the impact of these uncertainties on the decision-making process

NuScale implementation

- Performance requirements flow down / design process



- **Step 1**: establish high-level performance objectives / criteria
- **Step 2**: allocate those high-level performance objectives to products and develop additional system performance criteria through iterative and recursive design
- **Step 3**: Define key performance indicators (KPIs) based on important performance objectives to supporting performance-based decision making
- **Step 4**: Establish decision thresholds to allow for fast-tracking of decisions and changes
- **Step 5**: Monitor KPIs and effectiveness of decision making boards / groups, make adjustments as needed (*continues improvement*)

Plant technical requirements document (PTRD) – Level 0

- Defines top-level product requirements and allocates top-level technical requirements for NuScale plant configurations.
  - Primary input is Plant Concept Document (PCD)
- Requirements, goals, and objectives defined within the PTRD are further decomposed and allocated in the system design process
- Example performance-based safety objectives from PTRD
  - The plant shall be capable of cooling the NPM without external makeup water to replace UHS boil off for a minimum of 30 days.
  - After a design-basis event, the plant shall provide automated actions that place and maintain the nuclear power module (NPM) passively cooled with $k_{eff} < 1$ for at least 72 hours
  - Fuel thermal margin for normal operation and all anticipated operational occurrences (AOOs) shall be 5 percent greater than specified fuel design limits.
  - The plant shall maintain core damage frequency for internal beyond design basis events during full power operation, below 1E-7 per module critical year (mcyr).
  - Conditional containment failure probability shall be less than or equal to 0.1.

Parameters and limits reports – Level 1

- Define product-level:
  - Limits directly derived from the Plant Technical Requirements Document
  - Key discipline interface design parameters
- NuScale products are split into:
  - NuScale Power Module
  - Reactor Core and Fuel
  - Buildings
  - Protection, Monitoring, and Control (I&C)
  - Refueling and Handling
  - Balance of Site (Mechanical and Electrical support systems)

<u>Example</u>

Table 2-12. Shutdown Margin Limit

Condition	Mode Title	RCS Temperature
Mode 1	Operations	All ≥ Min. Temp. Criticality
Mode 2	Hot Shutdown	Any ≥ Min. Temp. Criticality
Mode 3	Safe Shutdown	All < Min. Temp. Criticality
Mode 4 & 5	Transition & Refueling	N/A
Cold Shutdown	-	N/A

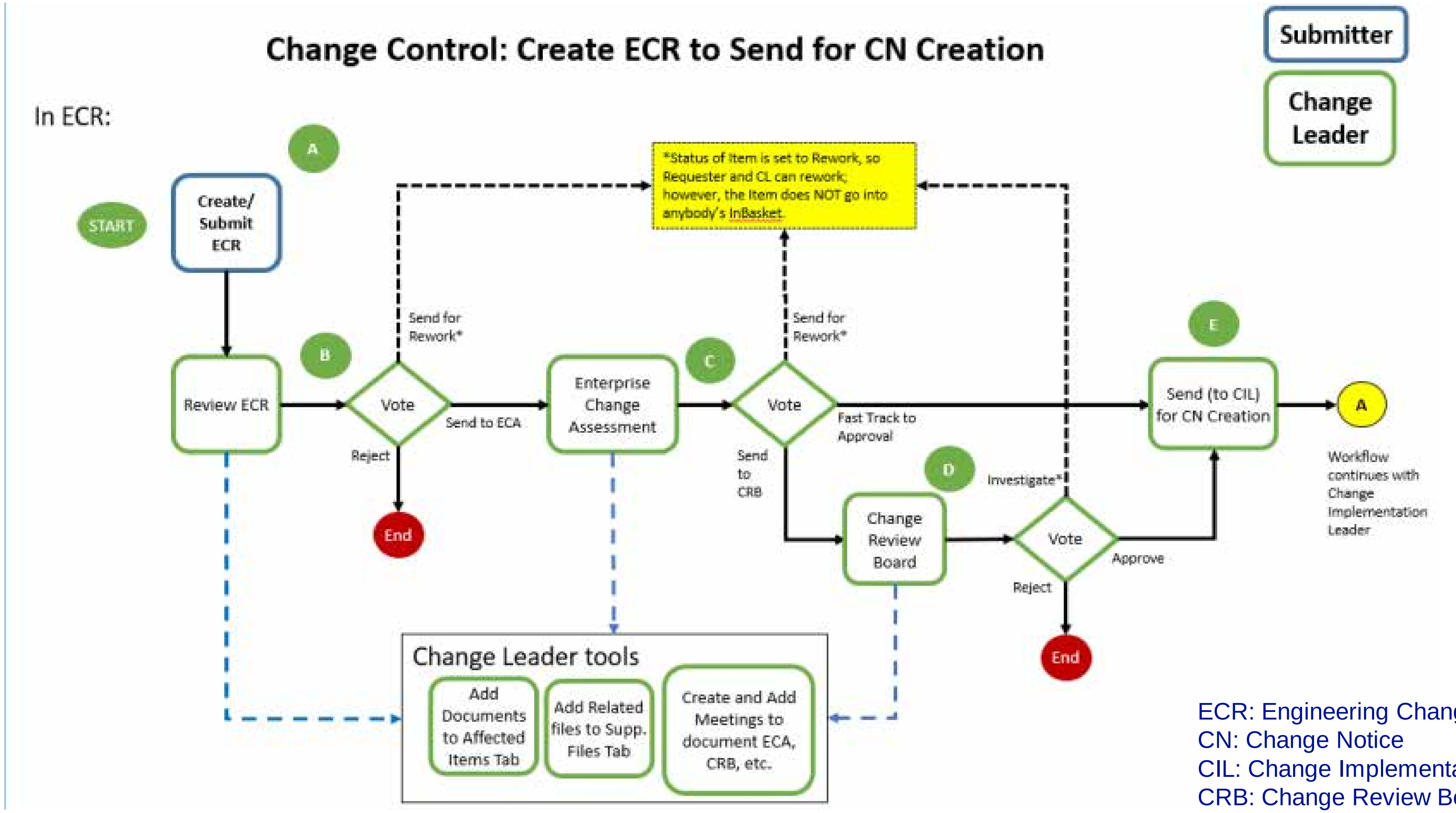
Technical measurement

- Activities used to provide the stakeholder insight into progress in the development and realization of the product and the associated risks and issues.
- Measurement insights help leadership make better decisions throughout the life cycle to increase the probability of delivering a product that meets both the specific requirements and stakeholder (e.g., customer) expectations.
- The four main types of technical measures are:
  - Measures of effectiveness (MOEs)
  - Measures of performance (MOPs)
  - Technical performance measures (TPMs)
  - Key performance parameters (KPMs)
- ***Key performance indicators (KPIs)*** are a project-critical subset of MOEs, MOPs, TPMs, and KPMs used to support timely and effective decisions.

Example

Key Performance Indicator (units)
Core thermal power (MWt)
Unit gross output (MWe)
House loads (MWe)
Fixed O&M ($M)
Variable O&M ($M)
Plant overnight capital cost ($M)
Emergency planning zone size (m)
Protected area size (acres)
Construction duration (months)
Minimum licensed reactor operators (persons)
Plant staff (persons)
Containment peak pressure margin (%)
Conditional containment failure probability (-)
Dose margin to Part 100 limits (%)
Fuel thermal margin, AOOs (%)

Enterprise change management / integrated decision making (CM-2 implementation)



Performance-based decision making

- All potential changes are evaluated against project-specific KPIs.
- Impact evaluations are qualitative, quantitative, timely, repeatable, and scalable.
- Most changes are fast-tracked (goal is 80%+) based on established KPI decision thresholds.

ECR: Engineering Change Control
CN: Change Notice
CIL: Change Implementation Leader
CRB: Change Review Board
ECA: Enterprise Change Assessment

D-RAP / performance-based decision making

- The objective of the D-RAP is to ensure that the plant is designed and constructed in a manner that is consistent with the risk insights and key assumptions (e.g., SSC design, reliability, and availability) from the probabilistic, deterministic, and other methods of analysis used to identify and quantify risk.
- Expert panels are a key element of successful D-RAP implementation
- At NuScale, decision making during D-RAP expert panel deliberations are based on criteria specified at the highest level that is feasible to meet functional objectives.
  - Allows for maximum flexibility for realizing successful system performance.
- The performance-based decision process has the following characteristics:
  - objective criteria to assess performance based on risk insights, deterministic analyses, and/or performance history
  - quantitative and qualitative RIPB decision criteria to support transparent and repeatable decisions recognition of different levels and types of DID when considering alternatives, including evaluation of safety margins
  - evaluation of tradeoffs on plant capital and operation cost versus risk reduction
  - adequate treatment of uncertainties in the PRA results and the impact of these uncertainties on the decision-making process

Summary and conclusions

- Draft ANS 30.3 provides requirements and guidance for advanced LWR designers for implementation of performance-based decision making
- NuScale has implemented key aspects of ANS 30.3 to support effective performance-based decisions:
  - Establish high-level safety objectives and allocate to SSCs through iterative and recursive design
  - Establish KPIs with decision thresholds (including fast track criteria)
  - Utilize KPIs in decision processes / boards
    - Engineering change control board
    - D-RAP expert panels
- NuScale has seen a marked improvement in the timeliness and effectiveness of decisions by utilizing KPIs and performance-based principles and methods
  - A key metric of effectiveness is the percentage of fast tracked decisions vs decisions that need board approval, which is now >85% (exceeding the 80% goal).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