Utility-Led Advanced Reactors Licensing Approach

Technology Inclusive Systematic Risk-Informed

vs.

Design Specific Prescribed-Risk-Informed

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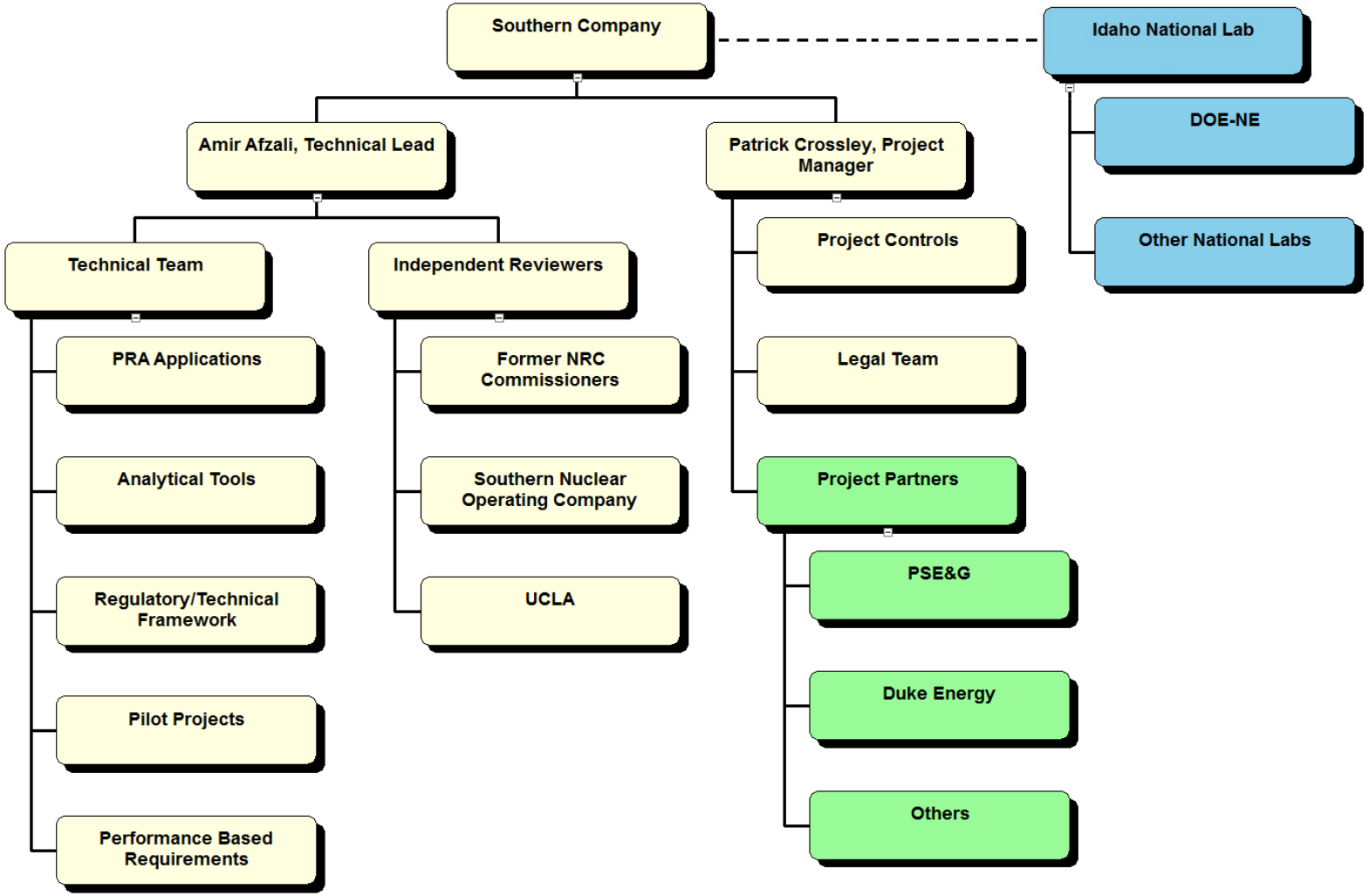
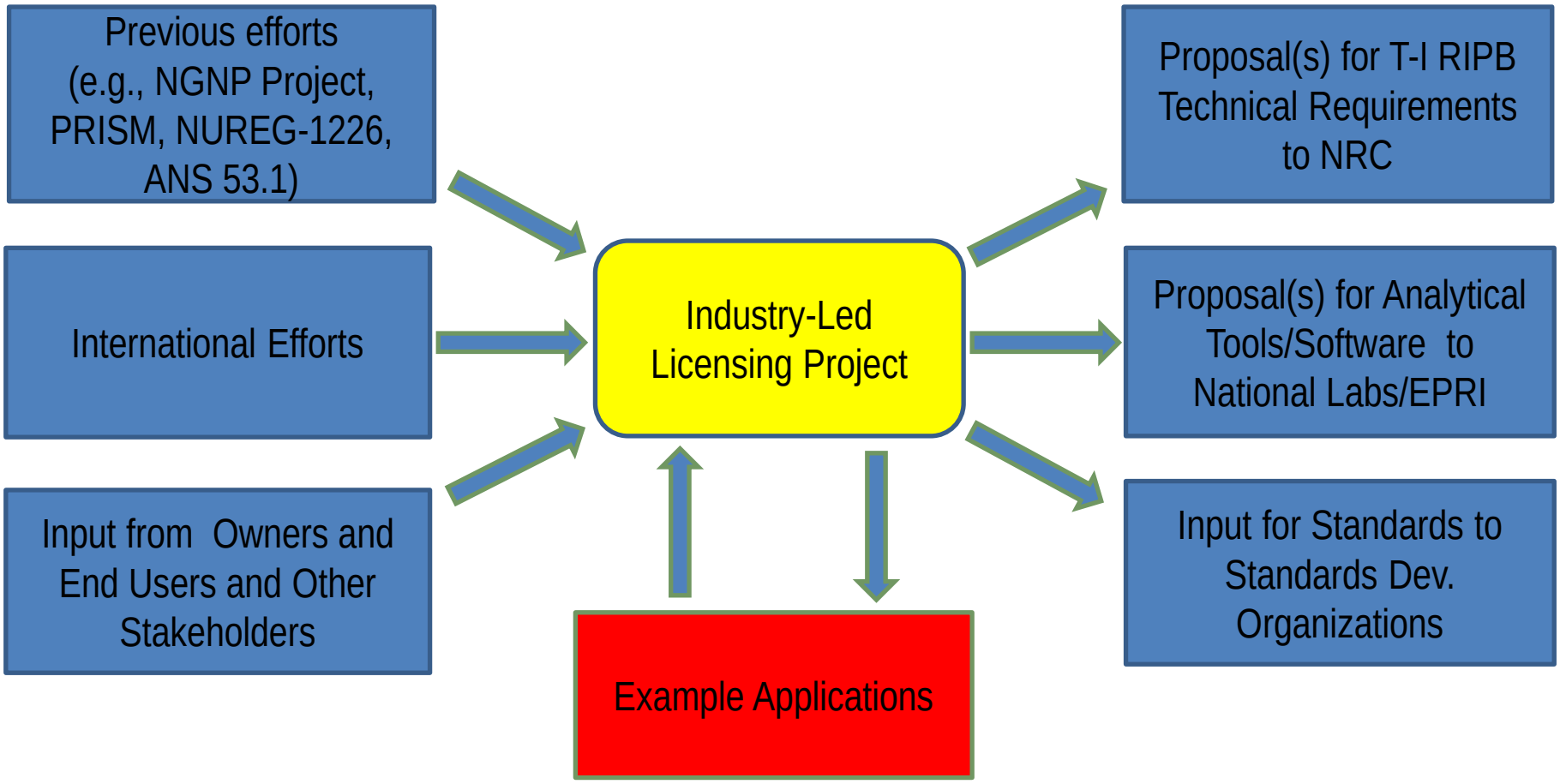
Key Attributes of the Utility-Led Initiative

- **Systematic Risk-Informed** to facilitate a systematic and robust consideration of the risk to the public during design and licensing
- **Performance-Based** to facilitate clear and (to the extent practical) direct relation between advanced reactor performance and the requirements
- **Technology-Inclusive** to enable and incentivize innovation across a broad spectrum of advanced reactor concepts

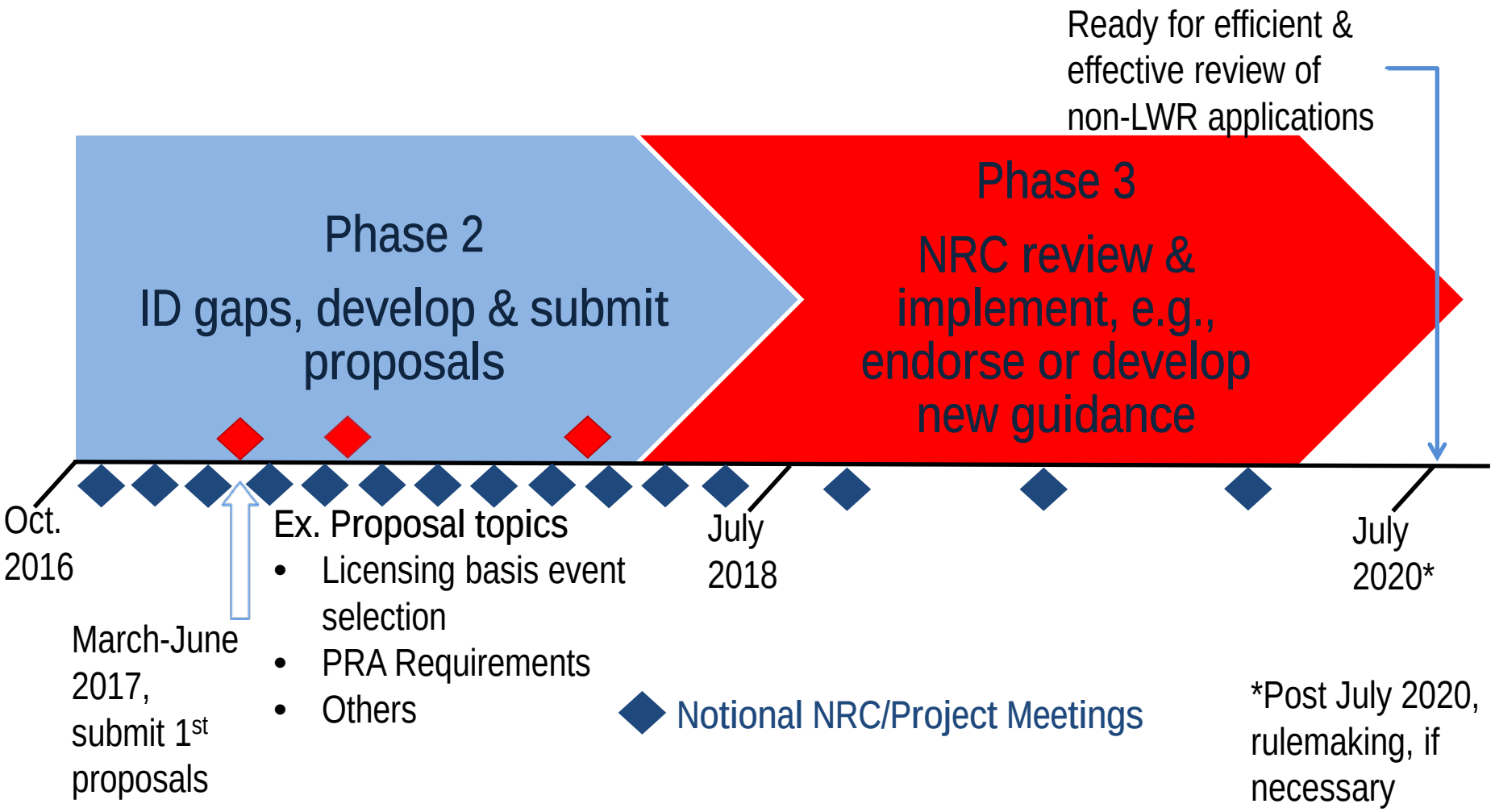
Structure of the Utility-Led Initiative



Input and Products



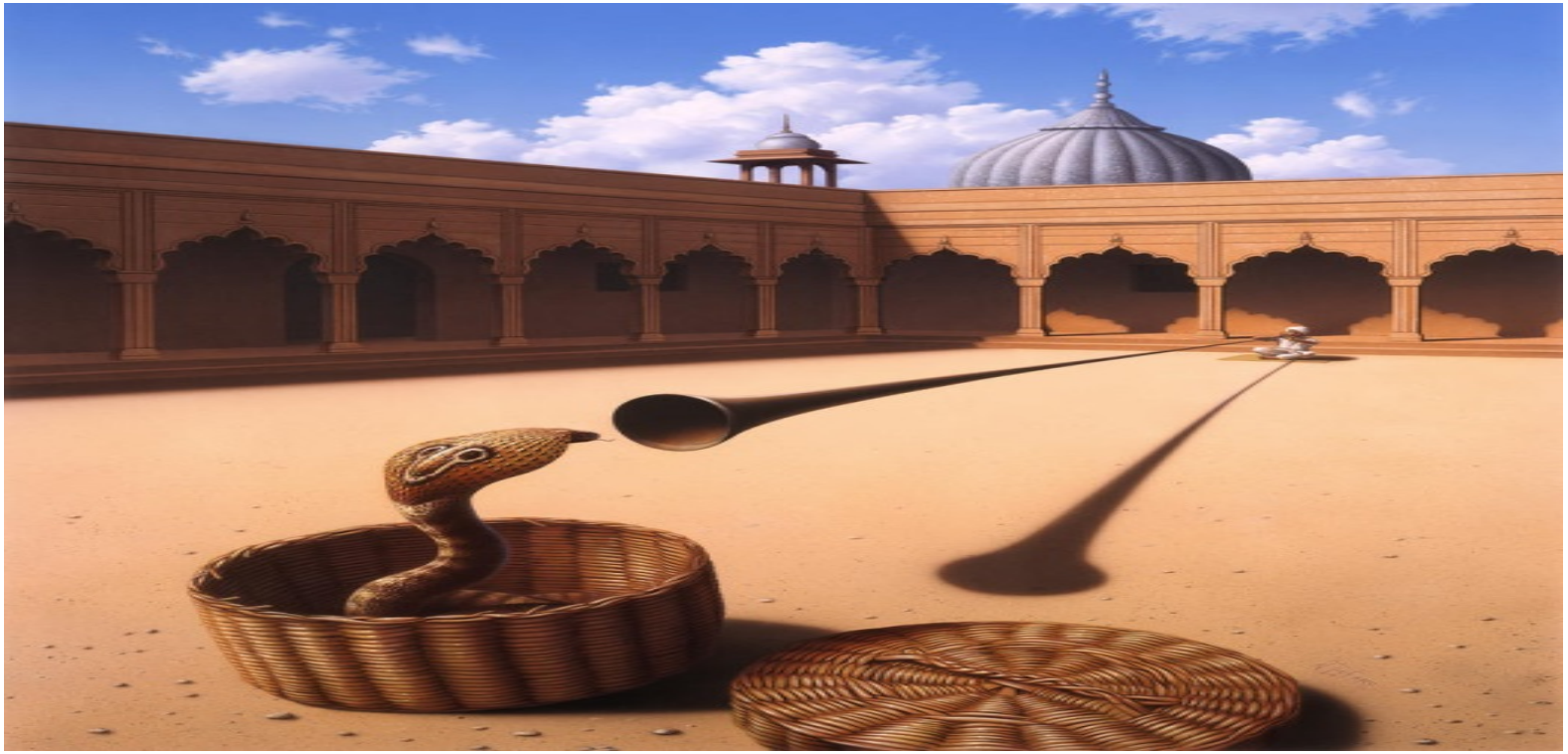
Utility-Led Licensing Initiative Timeline



Ground Rules

Rule 1: There is no desirable/practical “Zero” risk option

Ground Rules



Rule 2: Risk management through systematic Risk-Informed decision making process

Decision Making and Uncertainty

If a man will **begin with certainties** he shall **end in doubts**, but if he will be content to **begin with doubts**, he shall **end in certainties**.

Francis Bacon *The Advancement of Learning*, 1605.

Options for Establishing Requirements

- Prescribed-Risk-Informed (AKA “deterministic”)
  - Requirements are set by
    - Using engineering judgment to establish frequency of certain classes of bounding initiating events

      AND
    - Combination of **bounding deterministic** and **engineering judgments** to address uncertainties with respect to design response to these classes of initiators.
- Systematic-Risk-Informed (AKA Risk-Informed)
  - Requirements are set based on
    - Statistical evaluation of the frequency of possible initiators

      AND
    - Combination of **spectrum of deterministic**, **engineering judgment**, and **probabilistic evaluations** of accident prevention and mitigating functions response to each (class of) initiators.

Footnote: Deterministic -These are requirements which are purely based on deterministic analysis. For example, the amount of water required in the RWST where the amount of water is calculated based on mechanistic calculations.

Prescribed-Risk-Informed

- Universe of accidents is limited
  - unstructured, qualitative consideration of risk based on judgement
  - only single active failures are assumed in plant response evaluations
  - limited treatment of operator actions
- Use of margins to address uncertainties, based on **negotiated engineering judgment**
  - can lead to excessively and siloed conservative design
  - can lead to belief that Design Basis Accidents are limiting
- No assessment of relative risk significance (importance)
- No quantitative indication of risk to ease conservative decision-making

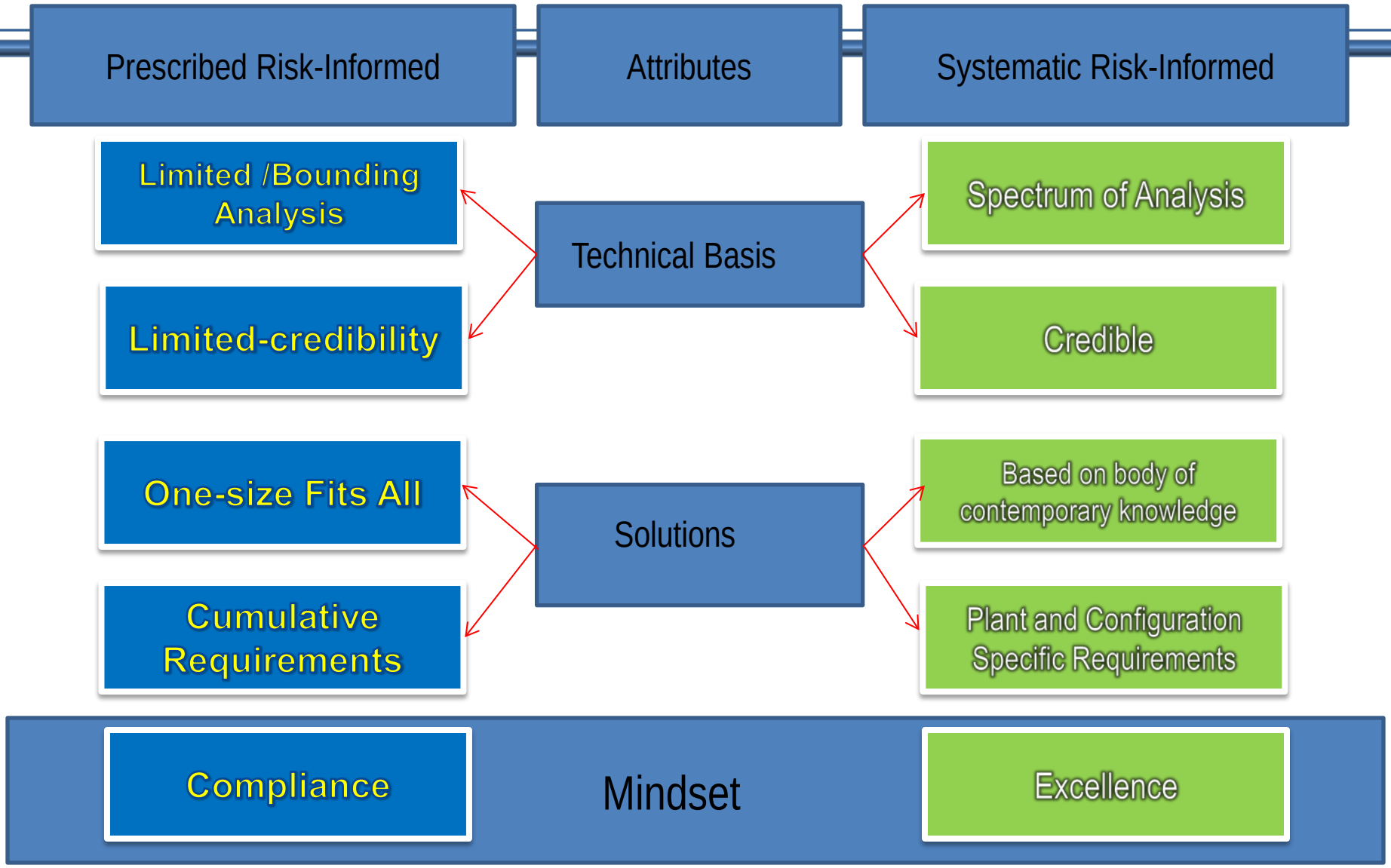
An ad hoc, non transparent, process potentially leading to major challenge to any design (particularly MSRs) development and deployment

Systematic-Risk-Informed

- Focused on determining the level of risk & the risk contributing features of the design and operations
  - PRA insights are used to identify accident initiators and inductively derive accident scenarios (i.e., not limited to pre-determined set of events plus single failures)
  - Analyzes multiple failures, including failures of redundant “barriers”
  - More extensive treatment of operator actions
  - Use of conservative margins avoided; focus on “best-estimate” analysis where possible and quantifies uncertainties; exposes real margins
  - Goes beyond Design Basis for potentially significant risk contirbutors
  - Assesses risk-importance of modeled elements
  - Provides quantitative results and a “model” for risk-informed decision-making

A systematic, data-driven process leading to transparent analytical decision making

PRI vs SRI Approach for Establishing Requirements



Elements of Risk-Informed Licensing Approach

1. *What* must be met
   - Top Level Regulatory Criteria (TLRC)
2. *When* TLRC must be met
   - Risk-informed Licensing Basis Events (LBEs)
3. *How* TLRC must be met
   - Safety Functions
   - SSC Safety Classification
   - Safety Design Criteria (General and Principal Design Criteria)
4. *How* well TLRC must be met
   - Quantitative SSC Design Criteria
   - Regulatory Special Treatment
   - Risk-Informed Defense-in-Depth (systematically addressing “adequate safety”)

Example- 10CFR52.79(a) and the Footnote

"The assessment must contain an analysis and evaluation of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site under the radiological consequence evaluation factors identified in paragraphs(a)(1)(vi)(A) and (a)(1)(vi)(B) of this section. In performing this assessment, an applicant **shall assume a fission product release** [5] from the core into the containment assuming that the facility is operated at the ultimate power level contemplated."

[5] "The fission product release assumed for this evaluation should be based **upon a major accident**, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events. **Such accidents have generally been assumed** to result in substantial meltdown of the core with subsequent release into the containment of appreciable quantities of fission products." *(emphasis added)*

Example- NGNP Proposed Alternative for 10CFR52.79(a)

The fission product release assumed for this evaluation should be based upon a major accident, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events. Such accidents will be based on a spectrum of limiting, mechanistically evaluated, risk informed LBEs supplemented by insights from credible (i.e., physically plausible) bounding event sequences. Such bounding event sequences will take into account the safety behavior of the plant, and the associated fission product release will be evaluated mechanistically.

Conclusions

- Prescribed Risk-Informed- Future designs vary from LWR basis
  - Risk minimization only achievable through maximizing each level of defense-in-depth through negotiation, resulting in cumulative patchwork requirements,
  - Compliant but unengaged and combative regulatory environment
- Systematic Risk-Informed- Future design risks best managed by integrated reallocation of resources, state-of-knowledge and state-of-practice improvements through systematic analysis
  - Holistic conservatism that focuses resources on the key choices that influence major risk-drivers.
  - Transparent and better managed Defense-in-Depth strategy embraced by implementers (utility and designers)