Use of Risk Information in Regulatory Activities

What Should You Learn?

- **We want you to be able to answer these questions:**
  - What is risk?
  - What metrics do we use to characterize risk?
  - How do we evaluate risk?
  - Why is risk information used?
  - What is risk-informed regulation?
  - Why aren’t our decisions risk-<u>based</u>?
  - How can risk organizations help you?

What Is Risk?

- **In everyday usage, "risk" is often used synonymously with the probability of a loss.**
- **In the NPP context, risk can be expressed as the "risk triplet":**
  - What can go wrong (accident scenario)?
  - How likely is it (frequency on a per reactor year basis)?
  - What are the consequences (impact on plant or on people)?

What Metrics Do We Use to Characterize Risk?

- **We characterize risk in terms of its effect on people**
  - Likelihood of prompt fatalities as a result of nuclear accidents
  - Likelihood of latent cancer fatalities as a result of nuclear accidents

- **Commission's safety goals determine how much risk is acceptable**
  - Policy Statement: *"Safety Goals for the Operations of Nuclear Power Plants," 8/21/1986*
  - Qualitative safety goals
    - Protect nuclear plants such that individual members of the public bear **no significant additional risk to life and health**.
    - Ensure that plants do not cause significant societal risk to life and health and have **risk comparable to or less than** risks of other electrical generation technologies
  - Quantitative health objectives
    - Even for people living right near a plant, the "nuclear risk" should be less than ***one-tenth of a percent*** **(1/1000) of the overall risk of death from accidents and cancer experienced by the average member of the U.S. population**
  - Subsidiary objective
    - Core damage frequency (CDF) no more than about **once every 10,000 years** per plant
  - Additional consideration
    - Large early release frequency (LERF) no more than about **once every 100,000 years** per plant

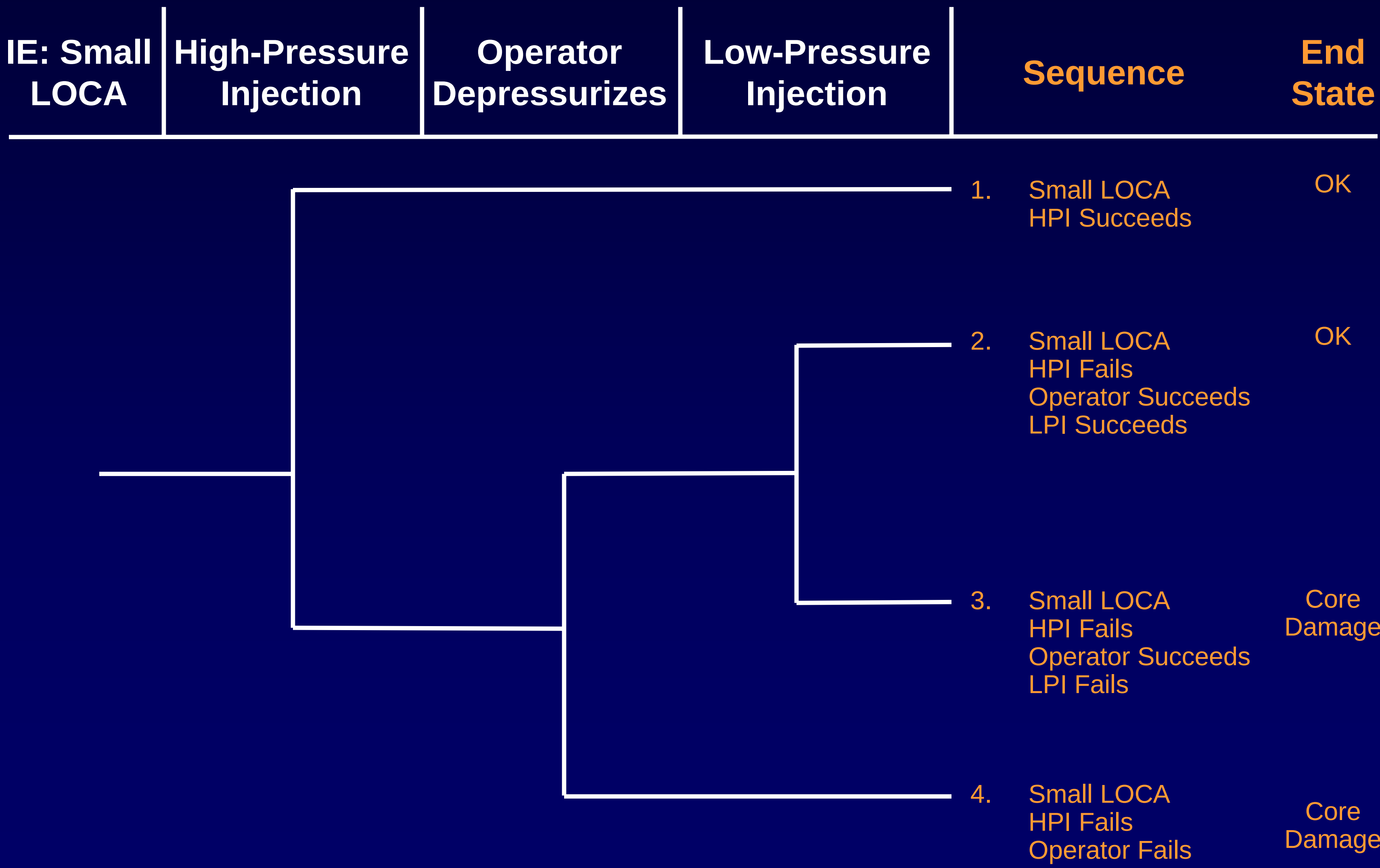
How Do We Evaluate Risk?

- **Probabilistic Risk Assessment (PRA) Methods**
  - One way of analyzing risk in the nuclear industry
  - PRA is a structured, analytical process for identifying potential weaknesses and strengths of a plant design in an integrated fashion
  - PRA provides a framework for explicitly addressing and presenting uncertainties (vs. making conservative assumptions to deal with uncertainty)

How Do We Evaluate Risk?

- **PRA Analysis Steps**
  - Initiating events
    - Circumstances that put a nuclear plant in an upset condition
      - Reactor trip, loss of offsite power, pipe break, etc.
    - Frequencies based on operational experience
  - Safety functions
    - Functions designed to mitigate the initiating event
      - Reactivity control (trip system), inventory control (safety injection), decay heat removal, etc.
    - Failure probabilities based on system models using operational experience data
  - Accident sequences
    - Combination of safety function successes **and** failures that describe the accident after an initiator
    - Logically displayed in an **event tree**
    - Result in an end state (often core damage or OK)
    - Quantified by combining initiator frequencies and failure probabilities of mitigating functions

How Do We Evaluate Risk?



What Results Do We Get?

- **PRA Results**
  - Significant Accident Sequences
    - An initiating event coupled with functional or system successes and failures that lead to core damage or large early release
  - Significant Accident Sequence Cutsets
    - Combinations of an initiating event and specific component failures and human failures that result in an accident sequence
  - Importance Measures
    - Can be used to measure the significance of a component or human action to causing, or preventing, core damage
  - Numerical estimates of:
    - **Core damage frequency (CDF)**
      - Frequency of the combinations of initiating events, hardware failures, and human errors leading to core uncovery with reflooding of the core not imminent
    - **Large early release frequency (LERF)**
      - Frequency of those accidents leading to significant, unmitigated releases from containment in a time-frame prior to effective evacuation of the close-in population such that there is a potential for early health effects
    - These estimates are easier to calculate than the health consequences and act as surrogates

What Does PRA Quality Mean?

- **A PRA used to support an application must be of sufficient quality to provide confidence in the results**
- **The Commission's direction is that, when possible, for efficiency and effectiveness, PRA quality should be judged against consensus standards**
- **PRA standards development is ongoing:**
  - ASME has developed a PRA standard for internal initiating events (e.g., transients, LOCAs)
  - ANS has developed a PRA standard for external initiating events (e.g., seismic, high winds)
  - ANS is developing a standard for internal fires and low power and shutdown modes of operation
- **The staff's endorsement of the standards and guidance on using them is provided in RG 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities"**
  - Currently addresses the ASME standard only

What is the Phased Approach to PRA Quality?

- **In December 2003, the Commission issued an SRM entitled “Stabilizing the PRA Quality Expectations and Requirements”**
- **A plan developed by the staff was submitted to the Commission in July 2004 as SECY-04-0118**
  - Defines a phased approach to achieving an appropriate quality for licensee PRAs for NRC’s risk-informed regulatory decision-making, benefiting from the development of PRA standards
  - Allows continued practical use of risk insights while progressing towards more complete and technically acceptable PRAs
  - Once a PRA standard for a scope item is complete and endorsed by the staff, the risk assessment of that scope item must be performed using a PRA if it is significant to the application under consideration

Why Is Risk Information Used?

- **Traditional analyses don't cover everything**
  - Original nuclear plant analyses were "**deterministic**"
    - Engineering judgment in determining accident categories and related prevention/mitigation capabilities
    - Reliance on worst case analyses, single failure criterion, defense-in-depth, and safety margins
    - Analyses performed separately by various disciplines
  - WASH-1400 (1975) assessed reactor risk
    - Revealed actual risk significant areas and interactions that were very different from the design basis events
    - Surprised the analysts!

Why Is Risk Information Used?

- **Commission's PRA policy statement**
  - *"Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities," 8/16/1995*
  - Four main statements:
    - **Increase use of PRA** to the extent supported by the state-of-the-art and in a way that **complements** traditional engineering approaches
    - Use PRA both to **reduce unnecessary conservatism** in current requirements and to support proposals for **additional regulatory requirements**
    - Be as **realistic** as practicable
    - Consider **uncertainties** appropriately when using the Commission's safety goals and subsidiary numerical objectives

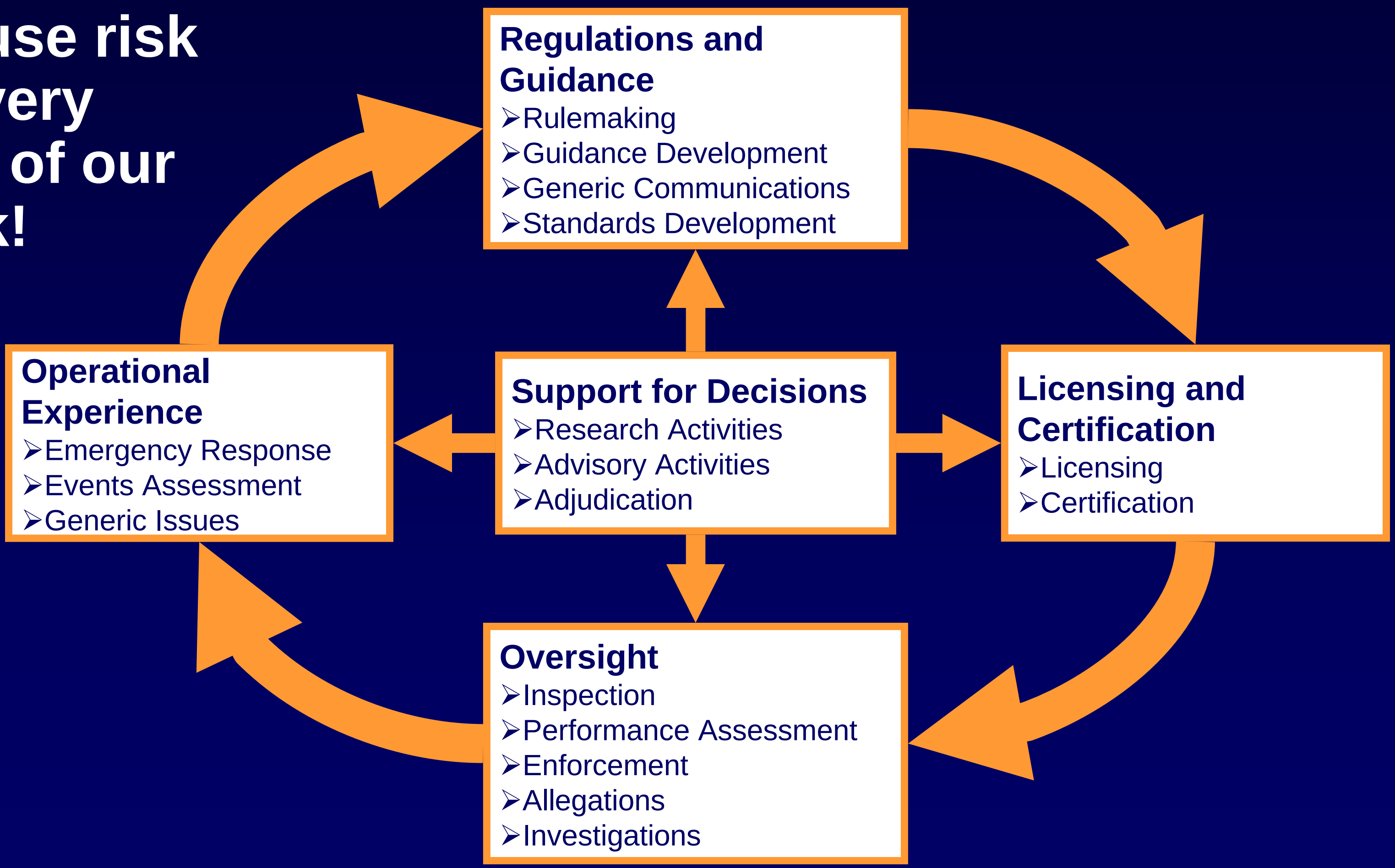
What Is Risk-Informed Regulation?

- A philosophy whereby risk insights are considered **together with other factors** to establish requirements that better focus licensee and regulatory attention on **design and operational issues commensurate with their importance** to health and safety.

- **Five principles for making risk-informed decisions**
  - The proposed change:
    - Meets current **regulations** (presumption of adequate protection)
    - Is consistent with the **defense-in-depth** philosophy
    - Maintains sufficient **safety margins**
    - Results in an increase in CDF or risk that is **small** and consistent with the intent of the Commission's Safety Goal Policy Statement
    - Will be monitored using **performance measurement** strategies

What Is Risk-Informed Regulation?

- **We use risk in every area of our work!**



What Is Risk-Informed Regulation?

- **Regulations and Guidance**
  - Completed risk-informed rules
    - 10 CFR 50.44, Combustible gas control
    - 10 CFR 50.48(c), Fire protection
    - 10 CFR 50.62, Anticipated transient without scram (ATWS)
    - 10 CFR 50.63, Station blackout
    - 10 CFR 50.65, Maintenance rule
    - 10 CFR 50.69, Special treatment requirements
  - Risk-informed rules in progress
    - 10 CFR 50.46a, Large break loss of coolant accident redefinition
    - 10 CFR 52, New reactor licensing (includes PRA requirements)
  - Under development
    - Risk-informed, performance-based, technology-neutral framework for regulation

What Is Risk-Informed Regulation?

- **Licensing and Certification**
  - **Voluntary** risk-informed licensing basis changes
    - General guidance
      - *Regulatory Guide (RG) 1.174, Standard Review Plan (SRP) 19*
    - Specific guidance:
      - Risk-informed technical specifications (TS) changes (completion times, surveillance frequencies)
        - » *RG 1.177, SRP 16.1*
      - Risk-informed inservice testing (IST) (pumps and valves)
        - » *RG 1.175, SRP 3.9.7*
      - Risk-informed inservice inspection (ISI) (piping)
        - » *RG 1.178, SRP 3.9.8*

What Is Risk-Informed Regulation?

- **Oversight**
  - Reactor Oversight Process
    - Risk-informed performance indicators
      - Mitigating Systems Performance Index (MSPI)
        - » *http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/mspi.html*
    - Risk-informed baseline inspections
    - Significance Determination Process for inspection findings
      - *Inspection Manual Chapter (MC) 0609 and appendices*
  - Enforcement Discretion
    - Notice of Enforcement Discretion (NOED)
      - *MC 9900 Technical Guidance*

What Is Risk-Informed Regulation?

- **Operational Experience**
  - Incident response
    - *Management Directive (MD) 8.3*
  - Event assessment
    - Risk-informed decision-making
      - *NRR Office Instruction LIC-504*
    - Accident Sequence Precursor (ASP) program

Why Aren't Our Decisions Risk-Based?

- "Risk-based" would mean we decide using only the numerical results of a risk assessment – if risk assessments are so helpful, why not?
  - We can't measure risk – we have to evaluate it using models
    - The models should address all contributors but do so with varying degrees of rigor and realism
    - Data on many failures or initiating events is sparse
    - Uncertainties are large, but in principle we know how to deal with them
  - However, we cannot know everything, and therefore our models are incomplete, e.g., there could be previously unknown failure mechanisms.
- **Therefore, we still consider traditional "deterministic" concepts such as defense-in-depth and safety margins, as well as performance monitoring, to accommodate our incomplete knowledge!**

What Did We Learn?

- **What is risk?**
  - What can go wrong? How likely is it? What are the consequences?
- **How do we measure risk?**
  - In terms of the public health consequences: prompt and latent (cancer) fatalities
- **How do we evaluate risk?**
  - Systematic, logical structure of a PRA to obtain surrogates (CDF and LERF) for public health consequences
- **Why is risk information used?**
  - Better decisions, more efficient use of resources, Commission policy
- **What is risk-informed regulation?**
  - Using risk insights <u>and</u> other factors to focus on issues commensurate with their impact on health and safety
- **Why aren't our decisions risk-<u>based</u>?**
  - Our risk models are incomplete because our state of knowledge is incomplete; need traditional approaches, too
- **How can risk organizations help you?**
  - Make integrated decisions, review risk-informed changes, provide risk insights