Risk-Informed Regulation at the U.S. NRC

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Reliability Engineering Education Program
The Center for Risk and Reliability
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NRC Oversight

Uranium Conversion

Uranium Enrichment

Power Reactors

Transportation

Storage

Waste Disposal

Medical/Industrial

New Reactors

The Traditional Approach to Regulation (Before Risk Assessment)

- **Management of uncertainty (unquantified at the time) was always a concern.**

- **Defense-in-depth and safety margins became embedded in the regulations (*structuralist* approach)**

- **"*Defense-in-Depth* is an element of the NRC's safety philosophy that employs successive compensatory measures to prevent accidents or mitigate damage if a malfunction, accident, or naturally caused event occurs at a nuclear facility."** [Commission's White Paper, February, 1999]

- **Questions that defense in depth addresses:**
  - **What if we are wrong?**
  - **Can we protect ourselves from the unknown unknowns?**

Design Basis Accidents

- A design basis accident is a postulated accident that a facility is designed and built to withstand without exceeding the offsite exposure guidelines of the NRC's siting regulation
- They are very unlikely events
- They protect against "unknown unknowns"

Technological Risk Assessment (Reactors)

- **Study the system as an integrated *socio-technical* system**

- **Probabilistic Risk Assessment (PRA) supports Risk Management by answering the questions:**

  - **What can go wrong? (thousands of accident sequences or scenarios)**
  - **How likely are these scenarios?**
  - **What are their consequences?**
  - **Which systems and components contribute the most to risk?**

What Did We Learn from the Reactor Safety Study?

<u>Prior Beliefs:</u>

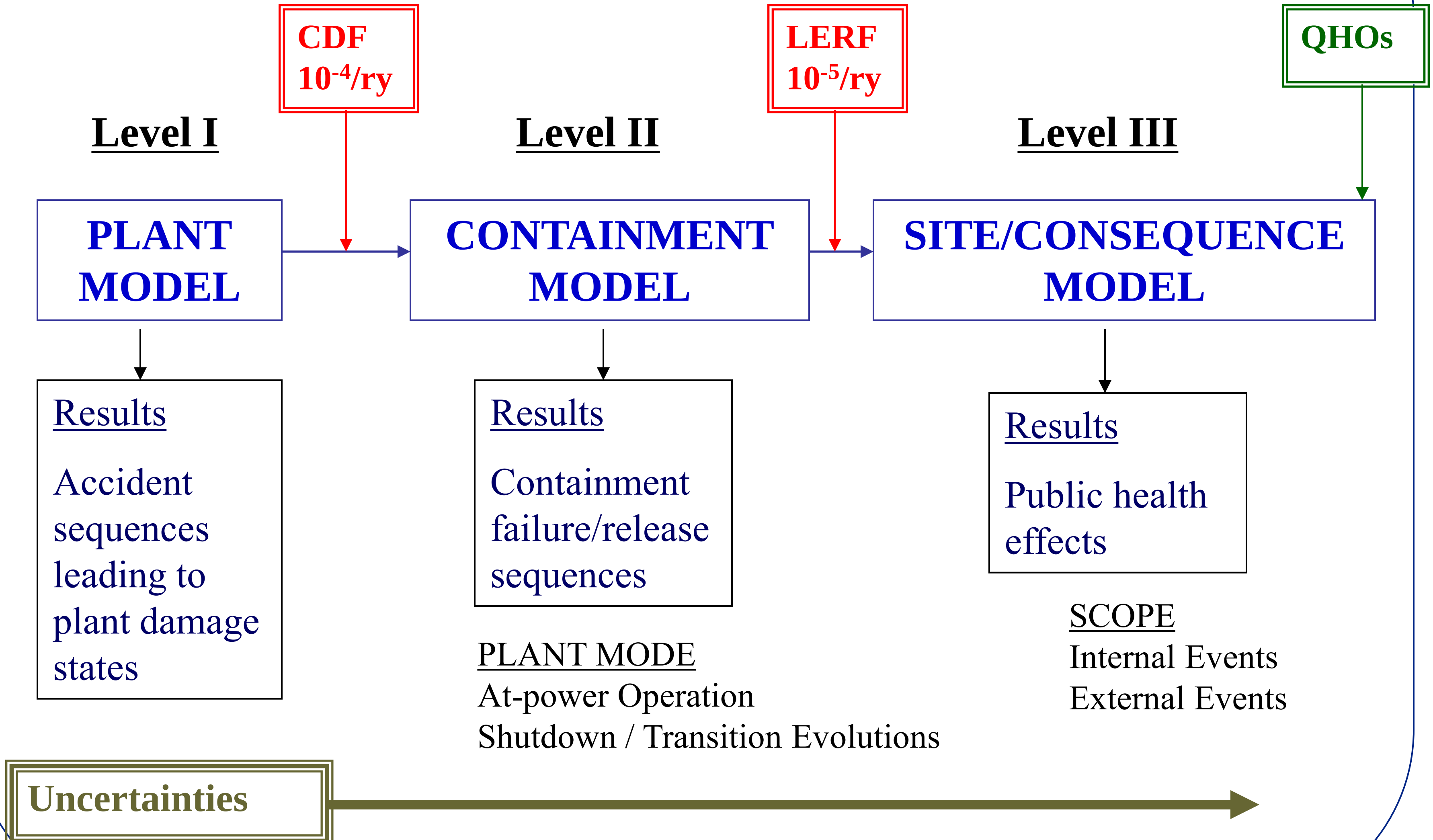
1. Protect against large loss-of-coolant accident (LOCA)
2. Core damage frequency (CDF) is low (about once every 100 million years, 10^{-8} per reactor year)
3. Consequences of accidents would be disastrous

<u>Major Findings</u>

1. Dominant contributors: Small LOCAs and Transients
2. CDF higher than earlier believed (best estimate: 5×10^{-5}, once every 20,000 years; upper bound: 3×10^{-4} per reactor year, once every 3,333 years)
3. Consequences significantly smaller
4. Support systems and operator actions very important

Beckjord et al, *Reliability Engineering and System Safety*, 39 (1993) 159-170.

PRA Model Overview and Subsidiary Objectives



PRA Policy Statement (1995)

- The use of PRA should be increased to the extent supported by the state of the art and data and in a manner that complements the defense-in-depth philosophy

- PRA should be used to reduce unnecessary conservatisms associated with current regulatory requirements

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

The Deliberation

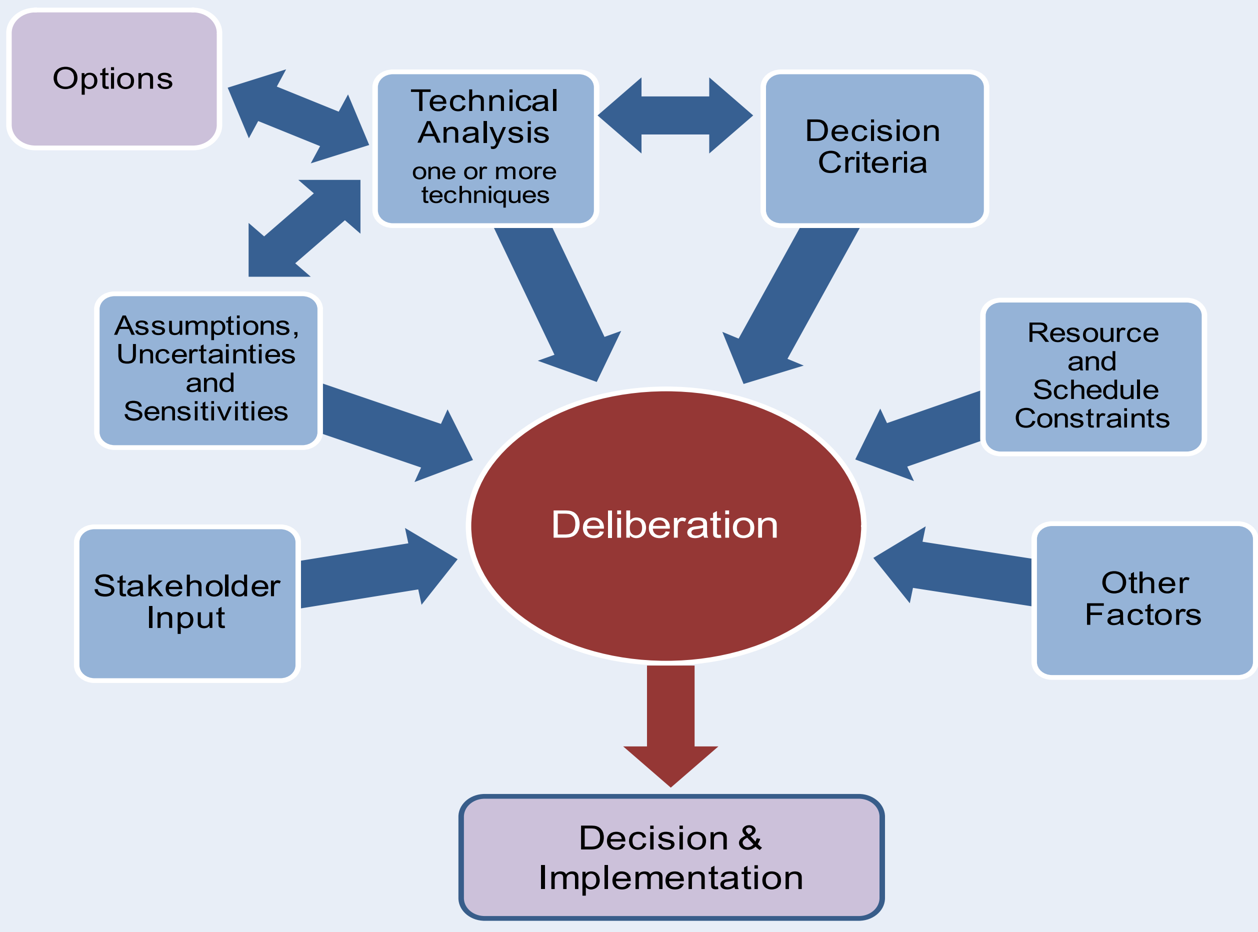


Figure 3-2 Deliberations

Evolution of the NRC's Risk-Informed Regulatory System

- 1980s: New or revised regulatory requirements based on PRA insights introduced
- 1990s: Risk-informed changes to a plant's licensing basis allowed
- 2000: Change to a risk-informed reactor oversight process made
- 2004: Risk-informed alternative to comply with fire protection requirements introduced
- 2007: Regulation requiring PRAs for licensing new reactors issued

Risk-Informed Decision Making in Regulation

- Improves Safety
  - New requirements (SBO, ATWS)
  - Design of new reactors
  - Focus on important systems and locations

- Makes regulatory system more rational
  - Reduction of unnecessary burden
  - Operating experience accounted for in regulations
  - Consistency in regulations

The Experience

- **Successes**
  - ➢ Maintenance rule
  - ➢ Risk-informed inservice inspection
  - ➢ Reactor oversight process

- **Challenges**
  - ➢ Fire protection
  - ➢ Special treatment requirements
  - ➢ Risk-informing Emergency Core Cooling System rule

Summary

- Uncertainties have always been of concern in safety
- Traditional methods manage uncertainties through design basis accidents and conservatism
- Risk assessment provides a global view of accident sequences, quantifies uncertainties, and is more realistic
- Risk-informed regulation combines the best features of both approaches