# Regulating Nuclear Power Plants

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# The U.S. Nuclear Regulatory Commission

- **Mission**: Ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment.
- Five Commissioners appointed by the President and confirmed by the U.S. Senate.
- Oversight: Senate Committee on Environment and Public Works and the House of Representatives.
- The Commission formulates policies, develops regulations governing nuclear reactor and nuclear material safety, issues orders to licensees, and adjudicates legal matters.
- All Commissioners vote on these issues.
  - Commissioners have an open-door policy

# Principles of Good Regulation

- Independence
  - Independence does not imply isolation. All available facts and opinions must be sought openly from licensees and other interested members of the public.
- Openness
- Efficiency
- Clarity
  - Regulations should be coherent, logical, and practical.
  - Agency positions should be readily understood and easily applied.
- Reliability
  - Regulations should be based on the best available knowledge from research and operational experience.
  - Once established, regulation should be perceived to be reliable and not unjustifiably in a state of transition.

# Advisory Committee on Reactor Safeguards

- Fifteen part-time experts from academia, national laboratories, and former industry managers
- Reviews and advises the Commission with regard to the licensing and operation of production and utilization facilities and related safety issues, the adequacy of proposed reactor safety standards, and other matters referred to it by the Commission.
- On its own initiative, may conduct reviews of specific safety-related items. Submits a report to the Commission commenting on the NRC Safety Research Program.
- Open meetings (exceptions: security, proprietary information)
- Formal letters and NRC staff responses

# New Rules

- ## The Adequate Protection Standard
  - "…under the adequate-protection standard of section 182(a), the NRC need ensure only an acceptable or adequate level of protection to public health and safety….."
- ## Safety Enhancement Measures
  - "If it so desires, however, the Commission may impose safety measures on licensees or applicants over and above those required by section 182(a)'s adequate-protection standard…. If the Commission wishes to do so, it may order power plants already satisfying the standard of adequate protection to take additional safety precautions. When the Commission determines whether and to what extent to exercise this power, it may consider economic costs or any other factors."

Court of Appeals for the D.C. Circuit, 1987.

# Rule 10 CFR 50.109 Backfitting

- Backfitting is defined as the modification of or addition to systems, structures, components, or design of a facility; or the design approval or manufacturing license for a facility; or the procedures or organization required to design, construct or operate a facility; any of which may result from a new or amended provision in the Commission's regulations or the imposition of a regulatory staff position interpreting the Commission's regulations that is either new or different from a previously applicable staff position

- The Commission shall require the backfitting of a facility only when it determines that there is a substantial increase in the overall protection of the public health and safety or the common defense and security to be derived from the backfit and that the direct and indirect costs of implementation for that facility are justified in view of this increased protection.

# The Traditional Approach to Regulation

## Prior to Risk Assessment (1975)

- **Management of (unquantified at the time) uncertainty was always a concern.**
- **Defense-in-depth and safety margins became embedded in the regulations.**
- **"*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." [USNRC White Paper, February, 1999]**

# Major Elements of Defense in Depth

Accident Prevention

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Safety Systems

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Containment

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Accident Management

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Siting & Emergency Plans

# Design Basis Accidents (Adequate Protection)

- **A DBA 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 stylized and very unlikely events.**
- **They protect against "unknown unknowns".**

# Problems with the Traditional Approach

- There is no guidance as to how much defense in depth is sufficient (unreliable regulations, slide 3)
- DBAs use qualitative approaches for ensuring system reliability (the single-failure criterion) when more modern quantitative approaches exist
- DBAs use stylized considerations of human performance (e.g., operators are assumed to take no action within, for example, 30 minutes of an accident's initiation)
- DBAs do not reflect operating experience and modern understanding
- Industry-sponsored PRAs showed a variability in risk of plants that were licensed under the same regulations.

# Probabilistic Risk Assessment

- **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?**

# Reactor Safety Study Insights
## (WASH-1400; 1975)

**Prior Beliefs:**

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

**Major Findings**

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

# Regulatory Decision Making

- **Regulatory decision making (like any decision) should be based on the current state of knowledge and should be documented (clear and reliable regulations, slide 3)**
  - ➢ **The current state of knowledge regarding design, operation, and regulation is key.**
  - ➢ **PRAs do not "predict" the future; they evaluate and assess future possibilities to inform the decision makers' current state of knowledge.**
  - ➢ **Ignoring the results and insights from PRAs results in decisions not utilizing the complete state of knowledge.**

# Quantitative Health Objectives (QHOs) (August, 1986)

- **Early and latent cancer mortality risks to an individual living near the plant should not exceed 0.1 percent of the background accident or cancer mortality risk, approximately**

**$5x10^{-7}$/year for early death and**

**$2 x10^{-6}$/year for death from cancer**

- ❖ **The prompt fatality goal applies to an average individual living in the region between the site boundary and 1 mile beyond this boundary.**
- ❖ **The latent cancer fatality goal applies to an average individual living in the region between the site boundary and 10 miles beyond this boundary.**

# Evolution of the USNRC'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
- **2000s:**
  - ➢ Change to a risk-informed reactor oversight process
  - ➢ Risk-informed alternative to comply with fire protection requirements
  - ➢ Regulation requiring PRAs for licensing new reactors

# Risk-informed Regulation

**"A risk-informed approach to regulatory decision-making represents 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 public health and safety."**

[Commission's White Paper, USNRC, 1999]

# The Deliberation (NUREG-2150)

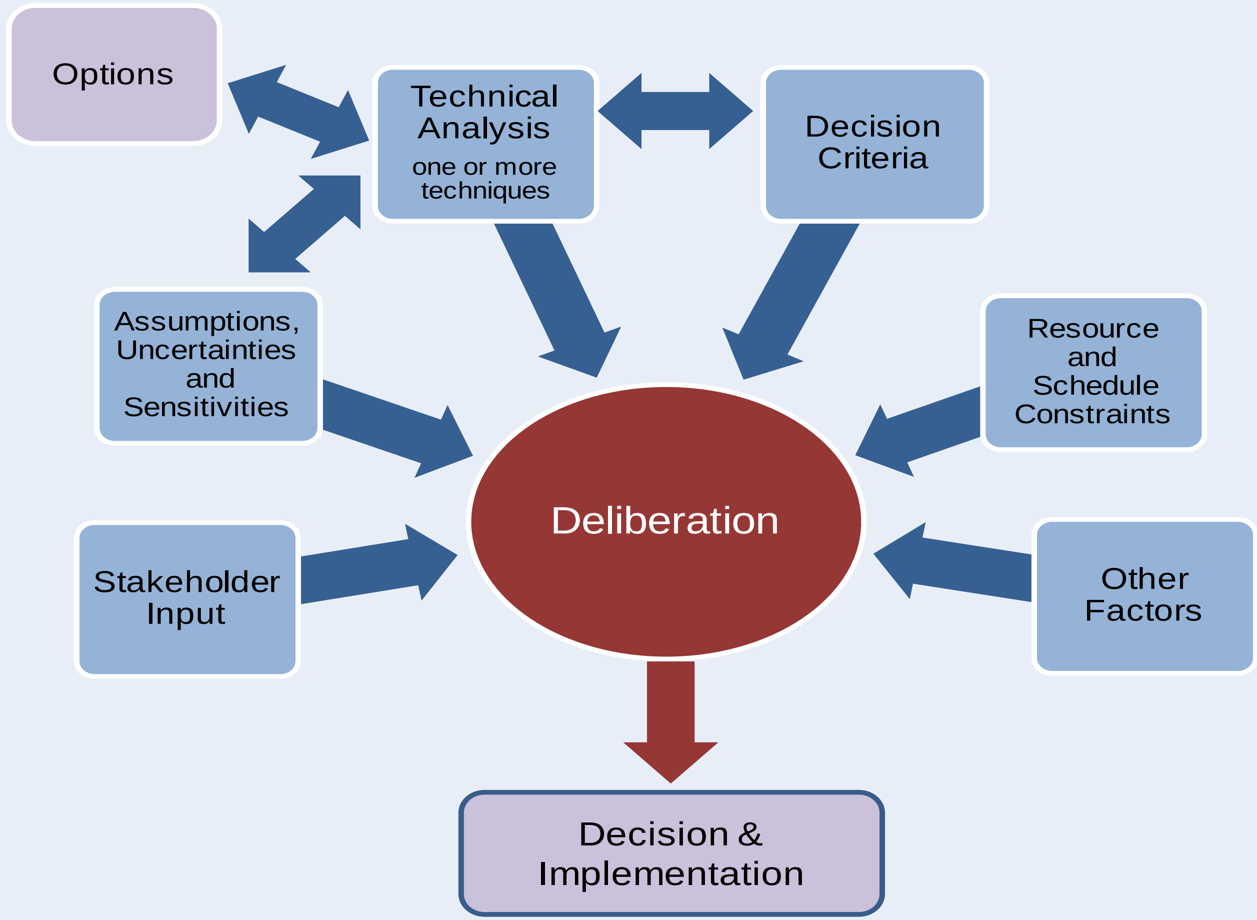


Figure 3-2 Deliberations

# Risk-Informed Framework

## *Traditional “Deterministic” Approach*

- Unquantified probabilities
- Design-basis accidents
- Defense in depth
- 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

# Confidence Building

- **Industry-sponsored PRAs for Zion and Indian Point NPPs**
  - **Reviewed extensively by the USNRC**
  - **Identified the significance of earthquakes and fires**
  - **Failure modes with easy fixes identified**
- **Early applications of risk-informed decision making**
  - **South Texas Project Experience**
  - **Allowed Outage Times extended from 3 days to 14 days for emergency AC power and 7 days for Essential Cooling Water and Essential Chilled Water systems.**
  - **Actual experience: Less than 5 days.**
- **PRA standards**