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Managing Uncertainties in the Regulation and Licensing of Nuclear Facilities

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U.S. Nuclear Regulatory Commission

Hochreiter Distinguished Lecture
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Penn State
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NRC Mission

- **To license and regulate the nation's civilian use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment.**

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NRC Oversight

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The Traditional Approach (Before Risk Assessment)

- **Management of (unquantified at the time) uncertainty 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 the structuralist defense in depth addresses:**
  - **What if we are wrong?**
  - **How can we protect ourselves from the unknown unknowns?**

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The Single-Failure Criterion

- **"Fluid and electric systems are considered to be designed against an assumed single failure if neither (1) a single failure of any active component (assuming passive components function properly) nor (2) a single failure of a passive component (assuming active components function properly), results in a loss of the capability of the system to perform its safety functions."**

- **The intent is to achieve high reliability (probability of success) without quantifying it.**

- **Looking for the worst possible single failure leads to better system understanding.**

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Design Basis Accidents

- **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 very unlikely events.**
- **They protect against "unknown unknowns."**

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Emergency Core Cooling System

- **An ECCS must be designed to withstand the following postulated Loss-of-Coolant Accident: a double-ended break of the largest reactor coolant line, the concurrent loss of offsite power, and a single failure of an active ECCS component in the worst possible place.**

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Technological Risk Assessment (Reactors)

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

<u>Probabilistic Risk Assessment (PRA) supports Risk Management by answering the questions:</u>

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

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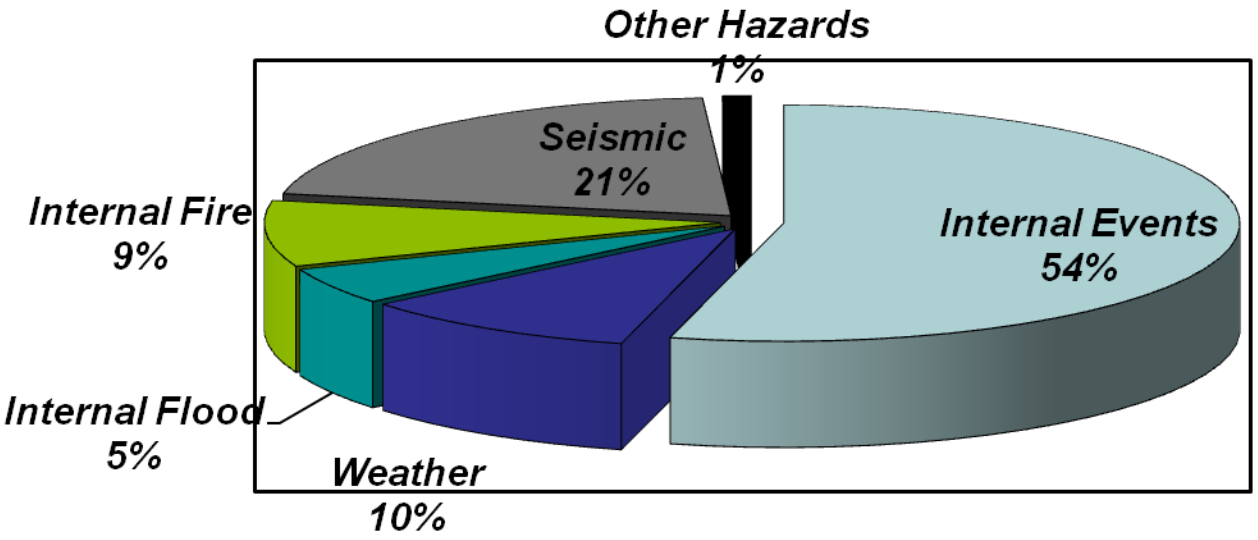
Seabrook at Power PRA - Contribution of Initiators to Core Damage Frequency (CDF)



CDF = 1.45E-5 / yr (mean value)

R. Turcotte presentation, MIT, 2008

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Risk Achievement Worth Ranking

Loss Of Offsite Power Initiating Event	51,940
Steam Generator Tube Rupture Initiating Event	41,200
Small Loss Of Coolant Accident Initiating Event	40,300
Control Rod Assemblies Fail to Insert	3,050
Common Cause Failure of Diesel Generators	271
RPS Breakers Fail to Open	202

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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.**

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Risk-Informed Framework

Traditional "Deterministic" Approaches

- Unquantified Probabilities
- Design-Basis Accidents
- Defense in Depth
- Can impose unnecessary regulatory burden

Risk-Informed Approach

- Combination of traditional and risk-based approaches

Risk-Based Approach

- Quantified Probabilities
- Scenario Based
- More realistic
- Incomplete
- Quality is an issue (Model uncertainty; Analyst or expert judgment)

- **All risk-informed initiatives are voluntary.**

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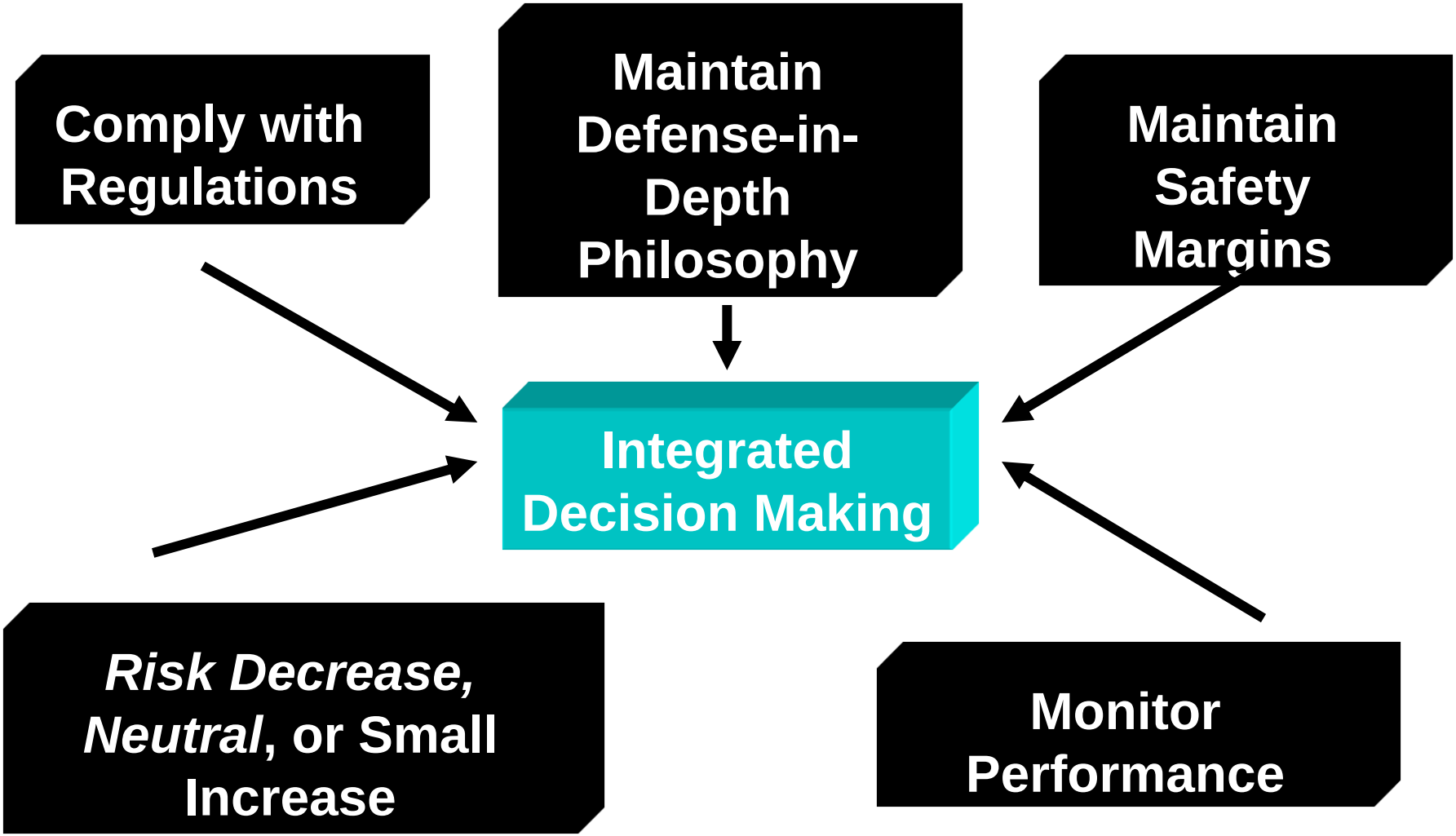
Risk-Informed Decision Making for Licensing Basis Changes (RG 1.174, 1998)



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Executive Order of 1/18/11

- **Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation.**
- **It must allow for public participation and an open exchange of ideas.**
- **It must promote predictability and reduce uncertainty.**
- **It must identify and use the best, most innovative and least burdensome tools for achieving regulatory ends.**
- **To the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt.**

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Current Status

- **The NRC has been moving its regulations in the direction of some key aspects of the Executive Order for quite some time now.**

- **Two great examples:**
  - **Reactor Oversight Process (ROP)**
  - **Risk-Informed In-Service Inspection (ISI)**

- **Utilizing risk information (event risk significance) is the key.**

- **Risk information has not yet been fully integrated into the reactor licensing process.**

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Licensing

- **10 CFR 52 (licensing of new reactors) requires an applicant to submit a PRA summary.**
- **Current review programs and guidance are still based on 10 CFR 50 (the traditional way of licensing).**
- **Staff Requirements Memorandum of July 2010 (COMGBJ-10-0004/COMGEA-10-0001).**

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New Task Force

- **Assess Options for a More Holistic Risk-Informed, Performance-Based Regulatory Approach.**

- **Develop a strategic vision and options for developing such a regulatory approach for reactors, materials, waste, fuel cycle, security, and transportation that would continue to ensure the safe and secure use of nuclear materials.**

- **Provide recommendations within one year.**

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Questions to be addressed (1)

- **Are the current practices adequate for accomplishing the goal of a holistic risk-informed and performance-based regulatory structure?**
- **How effective have past and on-going risk-informed initiatives been? What are the relevant lessons learned from these initiatives?**
- **Should the use of risk information continue to be voluntary?**
- **How effective have recent major deterministic licensing actions (i.e., license renewals, power uprates, B5b mitigation strategies) been? What are the relevant lessons learned from these actions?**
- **What are the visions for a holistic risk-informed, performance-based regulatory structure for reactors, materials, waste, fuel cycle, and security?**

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Questions to be addressed (2)

- **How can the transition from the current system to a more holistic risk-informed, performance-based regulatory structure be optimized?**
- **What is the schedule for achieving this regulatory structure?**
- **How should this structure be implemented?**
- **How should stakeholder input be considered?**
- **In each area, what are the capabilities and limitations of current probabilistic risk assessment methodologies?**

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Concluding Remarks

- **The concern about unknown unknowns creates conflicts in risk-informed decision making thus diminishing the benefits of a purely risk-based approach.**
- **The 1995 PRA Policy Statement states that PRA should be used to reduce unnecessary conservatisms associated with current regulatory requirements.**
- **What are "unnecessary conservatisms" is debatable.**
- **The introduction of risk information into the licensing process is in its infancy.**

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Japan

- NRC continues its monitoring and support
- NRC Task Force of senior leaders and experts. The task force will conduct a methodical and systematic review of relevant NRC regulatory requirements, programs, and processes, and their implementation, to recommend whether the agency should make near-term improvements to our regulatory system
- The task force will also identify a framework and topics for review and assessment for the longer-term effort
- The task force will update the Commission on the near-term review at approximately 30 and 60 days, and provide a written report and briefing at the completion of the near-term effort occurring at approximately 90 days