Opportunities and Challenges for Accident Risk Assessment and Management

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The Traditional Approach to Reactor Safety

- **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." [Commission's White Paper, February, 1999]**
- **Questions that defense in depth addresses:**
  - ➢ **What if we are wrong?**
  - ➢ **How can we protect ourselves from unknown unkowns?**
- **How much defense in depth is sufficient?**

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 are small in number.
- They protect against "unknown unknowns".

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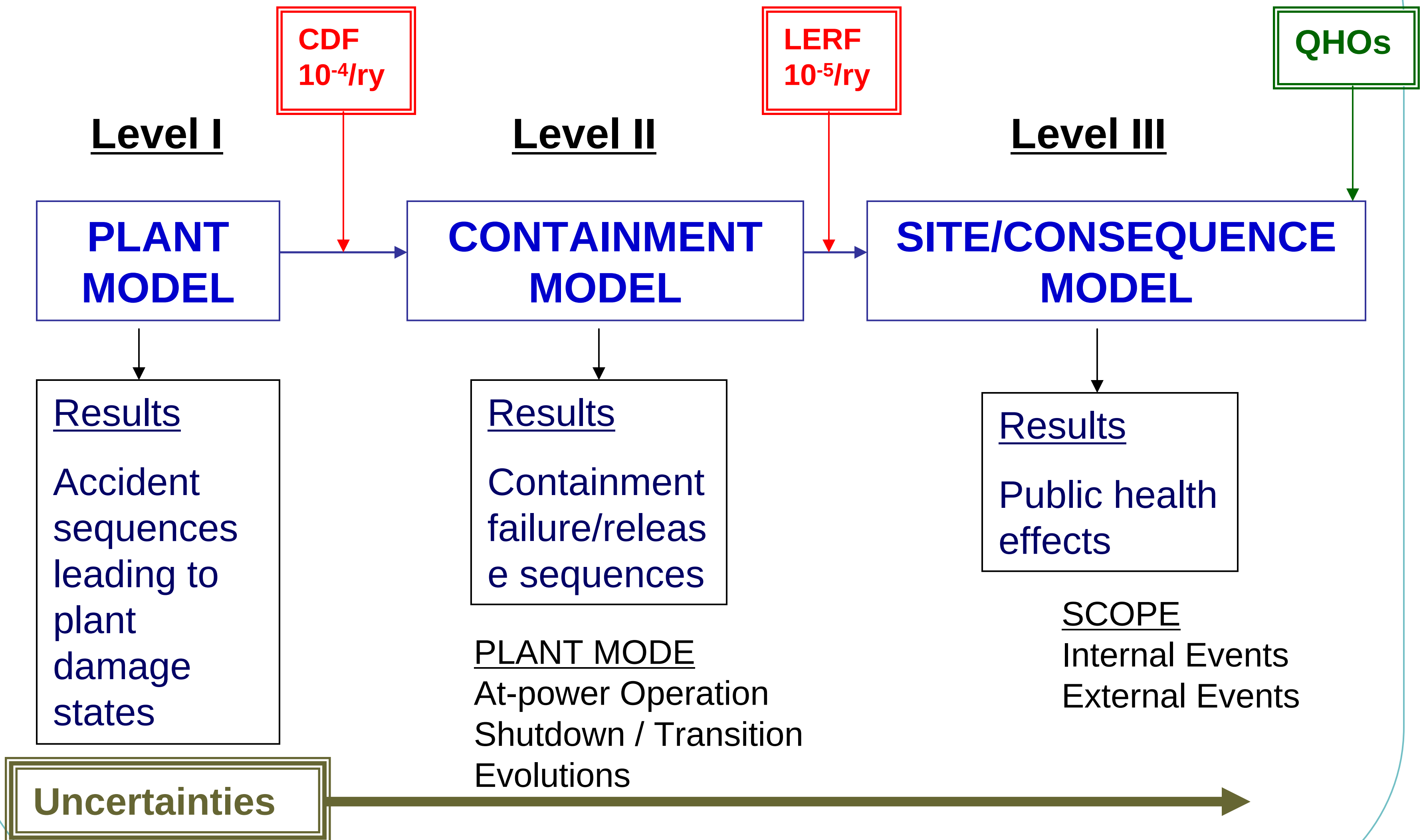
Technological Risk Assessment (Reactors)

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

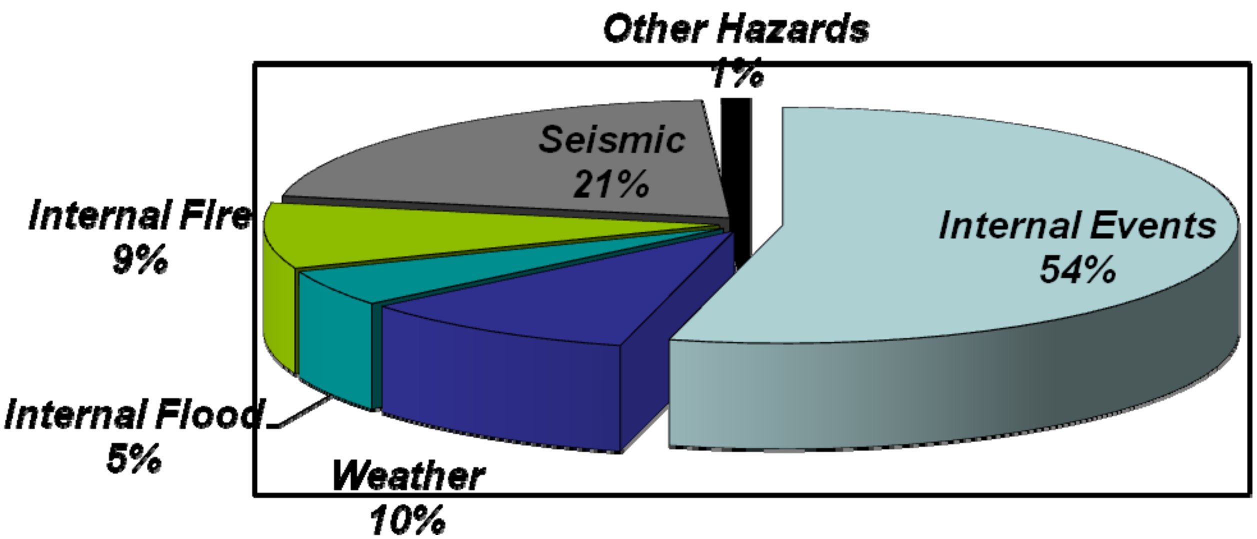
Probabilistic Risk Assessment (PRA) supports Risk Management by answering the questions:

- **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?**

PRA Model Overview and Subsidiary Objectives



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



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

R. Turcotte presentation, MIT, 2008

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

Level 3 PRA
Project Objectives

- **Develop a Level 3 PRA that:**
  - **Reflects technical advances since the last NRC-sponsored Level 3 PRAs were completed over 20 years ago**
  - **Addresses scope considerations that were not previously considered**
- **Extract new insights to enhance regulatory decision making and to help focus limited agency resources on safety-significant issues**
- **Enhance PRA staff capability and expertise, and improve documentation practices to make PRA information more accessible, retrievable, and understandable**
- **Demonstrate technical feasibility and evaluate the realistic cost of developing new Level 3 PRAs**

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Level 3 PRA Project Scope

- **Includes all site radiological sources (all reactor cores, spent fuel pools, and dry storage casks on site), all internal and external initiating event hazards, and all modes of operation**
- **Incorporates improvements in PRA technology and plant operational performance and safety since completion of NUREG-1150 "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants" (1990)**
- **Scheduled to be completed by March 2016**
- **Southern Nuclear Operating Company has volunteered Vogtle Units 1 and 2**

Challenges

- **Lack of PRA expertise**
  - **Problem for the NRC and the industry**
  - **Serious shortage in specialty areas (e.g., seismic, fire)**
  - **NRC Staff "Grow-Your-Own Program"**
    - ✓ **For NRC staff interested in applying for a training and qualification program to become a PRA Analyst**
- **Need to further increase understanding of the value and use of risk concepts within the agency and externally**

SMR Risk-Informed Review Initiative

- **Development of a framework to more fully integrate the use of risk insights into SMR reviews**
- **Development of risk-informed licensing review plans**
- **Goal of enhanced safety focus appropriate to SMRs and increased efficiency**
- **NRC evaluating longer term options for a more risk-informed regulatory structure for advanced reactors**

Risk Management Task Force (RMTF)

- **Task Force for Assessment of Options for a More Holistic Risk-Informed, Performance-Based Regulatory Approach formed in February 2011**

- **Task Force charter is to**
  - **develop a strategic vision and options for adopting a more comprehensive and holistic risk-informed, performance-based regulatory approach for reactors, materials, waste, fuel cycle, and transportation that would continue to ensure the safe and secure use of nuclear material**

- **Final report in April 2012**

RMTF Approach

- **Provide a vision for a regulatory system 10-15 years in the future**
- **The approach should build on the experience of the last 20 years and should be evolutionary rather than revolutionary**
- **The need for a new regulatory approach was also recognized by the NRC's Fukushima Near-Term Task Force Recommendation 1:**

  "Establish a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations."

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A Proposed Risk Management Regulatory Framework

Mission

Ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment

Objective

Manage the risks from the use of byproduct, source and special nuclear materials through appropriate performance-based regulatory controls and oversight

Risk Management Goal

Provide risk-informed and performance-based defense-in-depth protections to:

- Ensure appropriate barriers, controls, and personnel to prevent, contain, and mitigate exposure to radioactive material according to the hazard present, the relevant scenarios, and the associated uncertainties; and
- Ensure that the risks resulting from the failure of some or all of the established barriers and controls, including human errors, are maintained acceptably low

Decision-Making Process

Use a disciplined process to achieve the risk management goal:

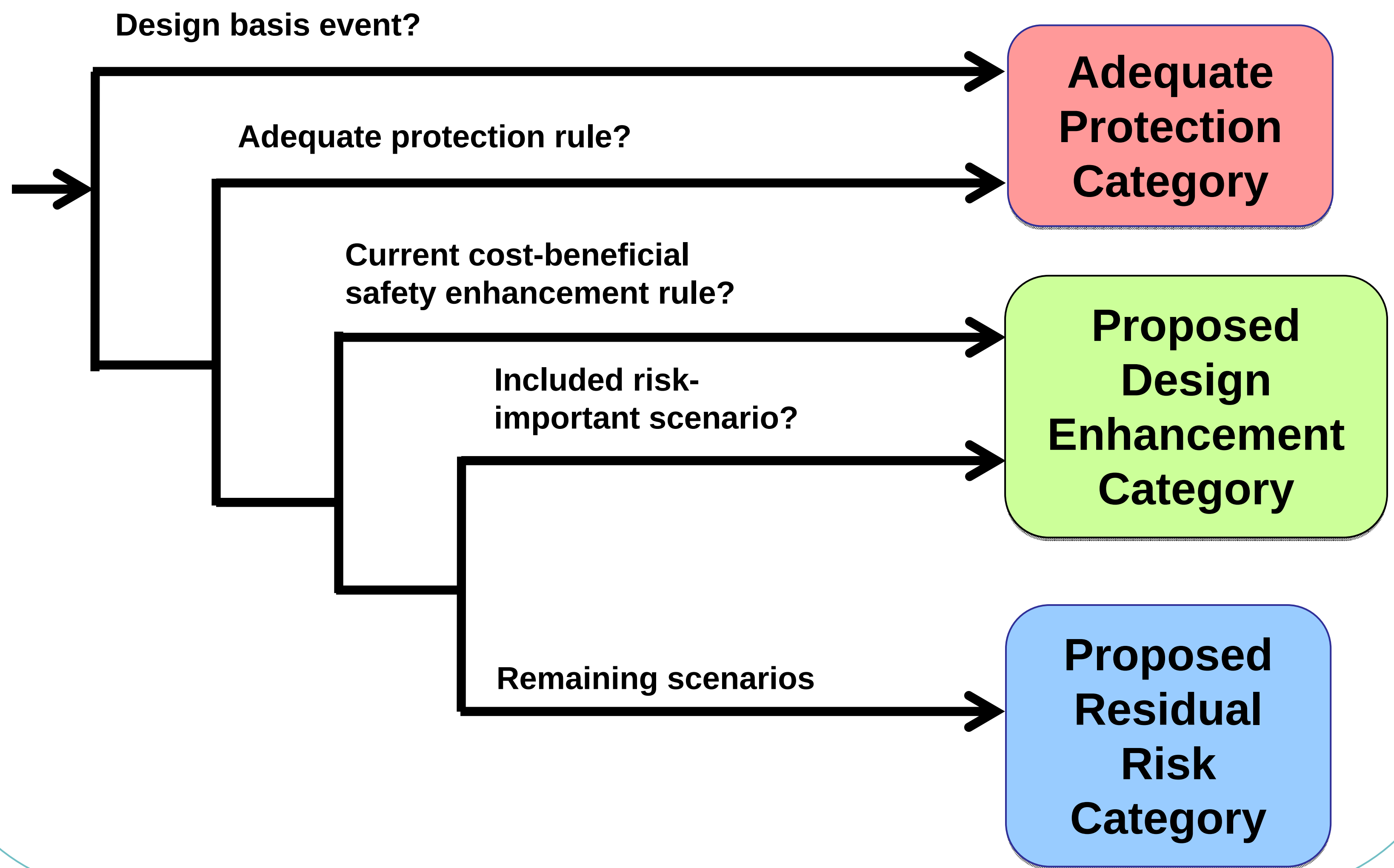
Identify issue → Identify Options → Analyze → Deliberate → Implement Decision → Monitor → Identify issue

Operating Reactor Recommendations

The set of design basis events/accidents should be reviewed and revised, as appropriate, to integrate insights from the power reactor operating history and more modern methods such as PRA.

NRC should establish via rulemaking a *design enhancement category* of regulatory treatment for beyond-design-basis accidents. This category should use risk as a safety measure, be performance-based (including the provision for periodic updates), include consideration of costs, and be implemented on a site-specific basis.

Proposed Regulatory Framework: Power Reactors



Design Enhancement Characteristics

Proposed Design Enhancement Category

- **Who decides what is included?**
  - NRC specifies initiators or scenarios
  - Licensees use site-specific PRAs
- **What criteria are used for inclusion?**
  - Initiating events with frequency greater than xx
  - Accident sequences with frequency greater than yy
  - Cost-beneficial rules
- **What criteria are used for disposition?**
  - Risk less than zz
  - ALARA
  - Combination