Application of Risk Assessment and Management to Nuclear Safety

George Apostolakis
Commissioner
US Nuclear Regulatory Commission
CmrApostolakis@nrc.gov

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The Pre-PRA Era

- **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]**

- ***Design Basis Accidents*** **are postulated accidents that a nuclear facility must be designed and built to withstand without loss to the systems, structures, and components necessary to assure public health and safety.**

Evolution of PRA Development

- **Reactor Safety Study (WASH-1400; 1975)**
- **Individual Plant Examinations (1988)**
- **NUREG-1150 (Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants, 1990)**
- **Plant-specific PRAs**
  - ➢ **Licensees**
  - ➢ **NRC**
- **State-of-the-Art Reactor Consequence Analyses (SOARCA, 2012)**
- **Level 3 PRA Project**

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Quantitative Safety Goals of the Nuclear Regulatory Commission (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 5×10^{-7}/year for early death and 2×10^{-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.

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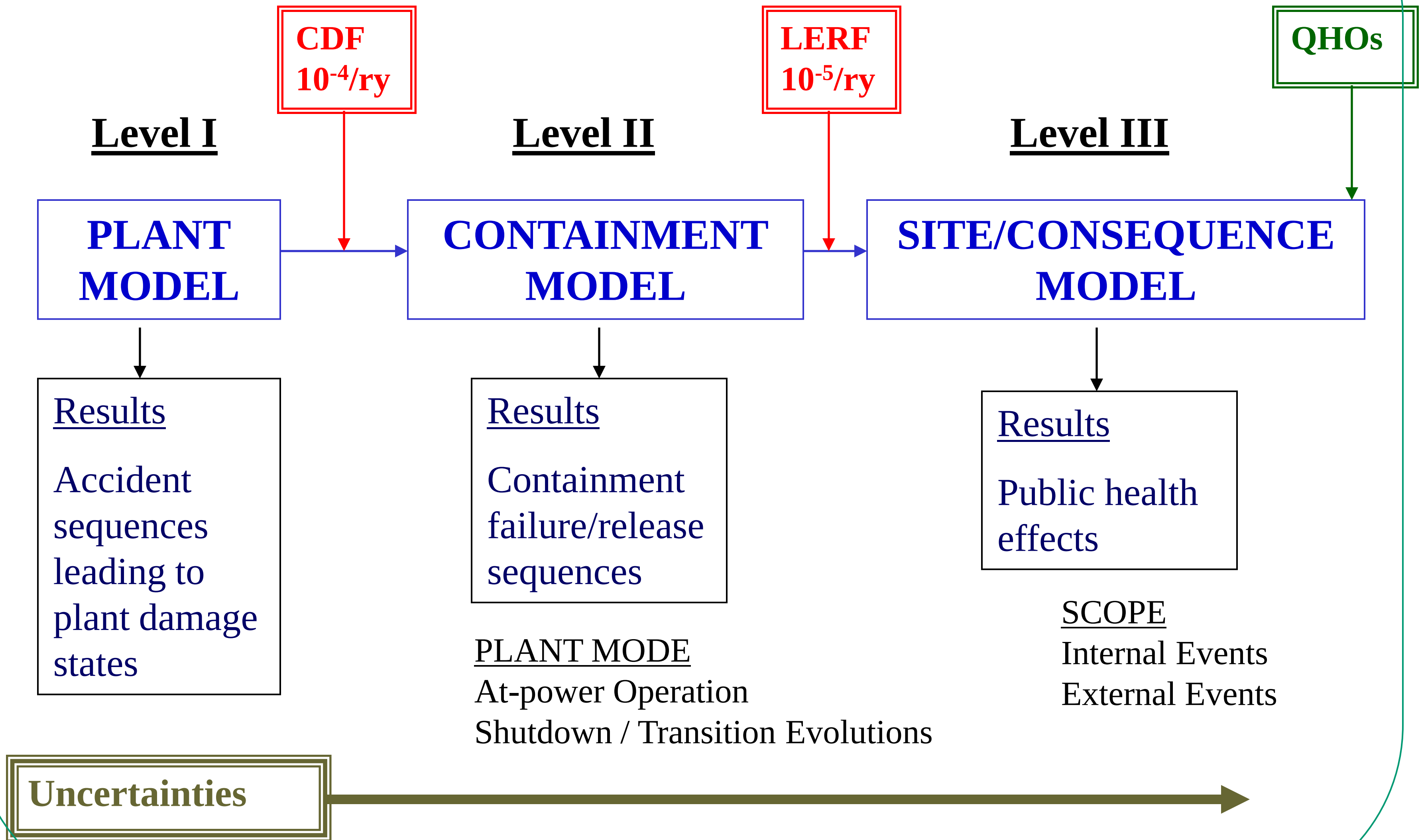
PRA Model Overview and Subsidiary Objectives



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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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Evolution of the Risk-Informed Regulatory System

- **Regulatory Requirements**
  - **Anticipated Transients without Scram (ATWS)**
  - **Station Blackout (SBO)**
  - **Maintenance Rule**
- **Risk-Informed Changes to the Licensing Basis**
  - **Regulatory Guide 1.174**
  - **Technical Specification Improvement Initiatives**
  - **Risk-Informed In-Service Inspection**
  - **Special Treatment/Categorization Pilot (10 CFR 50.69)**
- **New Reactor Licensing**
- **Reactor Oversight Process**
- **Fire Protection**

Risk Management Task Force (RMTF)

- **Suggested by Chairman Jaczko in late 2010**
- **Task Force formed in February 2011**
- **Charter**

> ***"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."***

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Fukushima Near-Term Task Force Recommendation 1

- **"This regulatory approach, established and supplemented piece-by-piece over the decades, has addressed many safety concerns and issues, using the best information and techniques available at the time. The result is a patchwork of regulatory requirements and other safety initiatives, all important, but not all given equivalent consideration and treatment by licensees or during NRC technical review and inspection."**

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

- **NRC staff proposal to be submitted to Commission in early 2013**

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A Proposed Risk Management Regulatory Framework (NUREG-2150)

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:

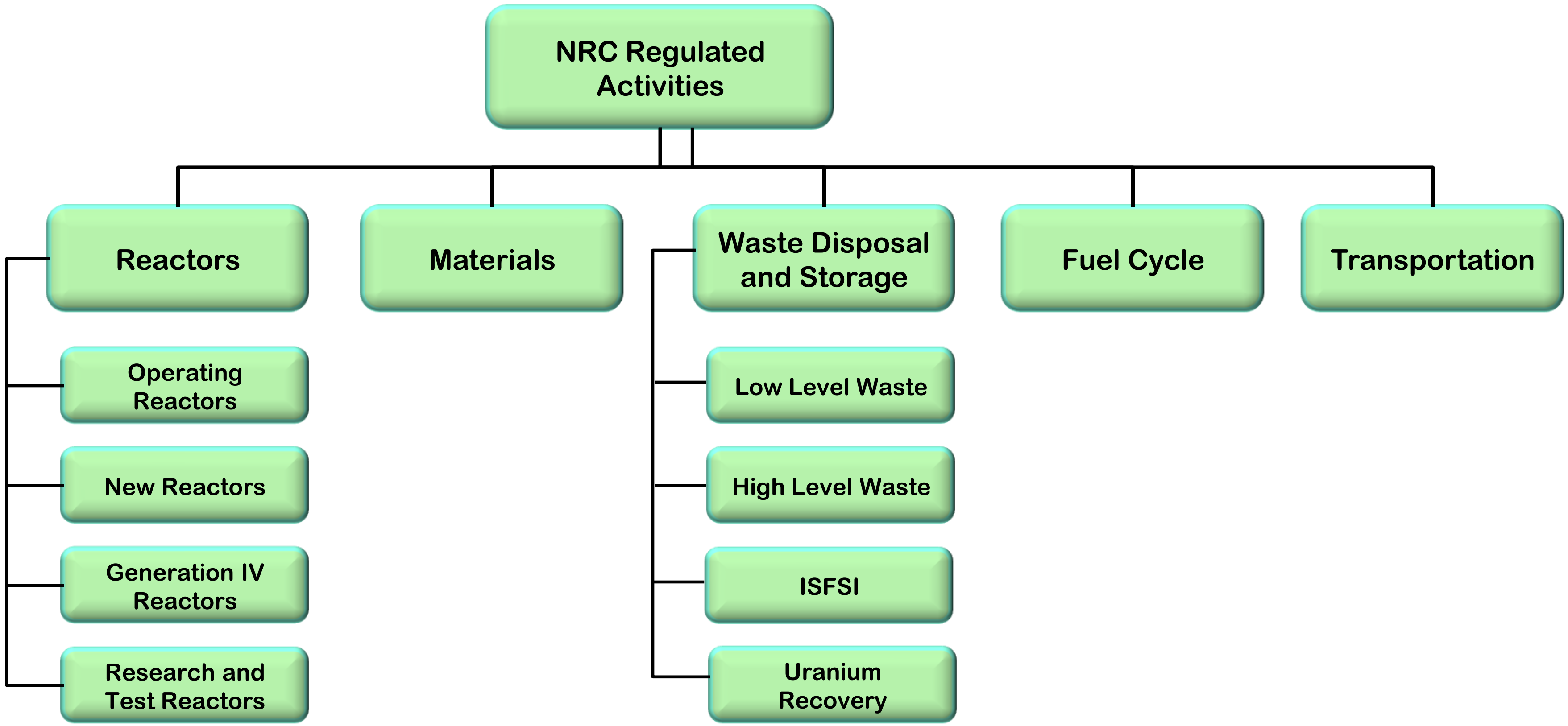
- Ensure appropriate barriers, controls, and personnel to prevent, contain, and mitigate exposure to radioactive material according to the hazard present, the relevant scenarios, and the associated uncertainties; and
- Ensure that the risks resulting from the failure of some or all of the established 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 → (back to Identify issue)

Diversity of Activities

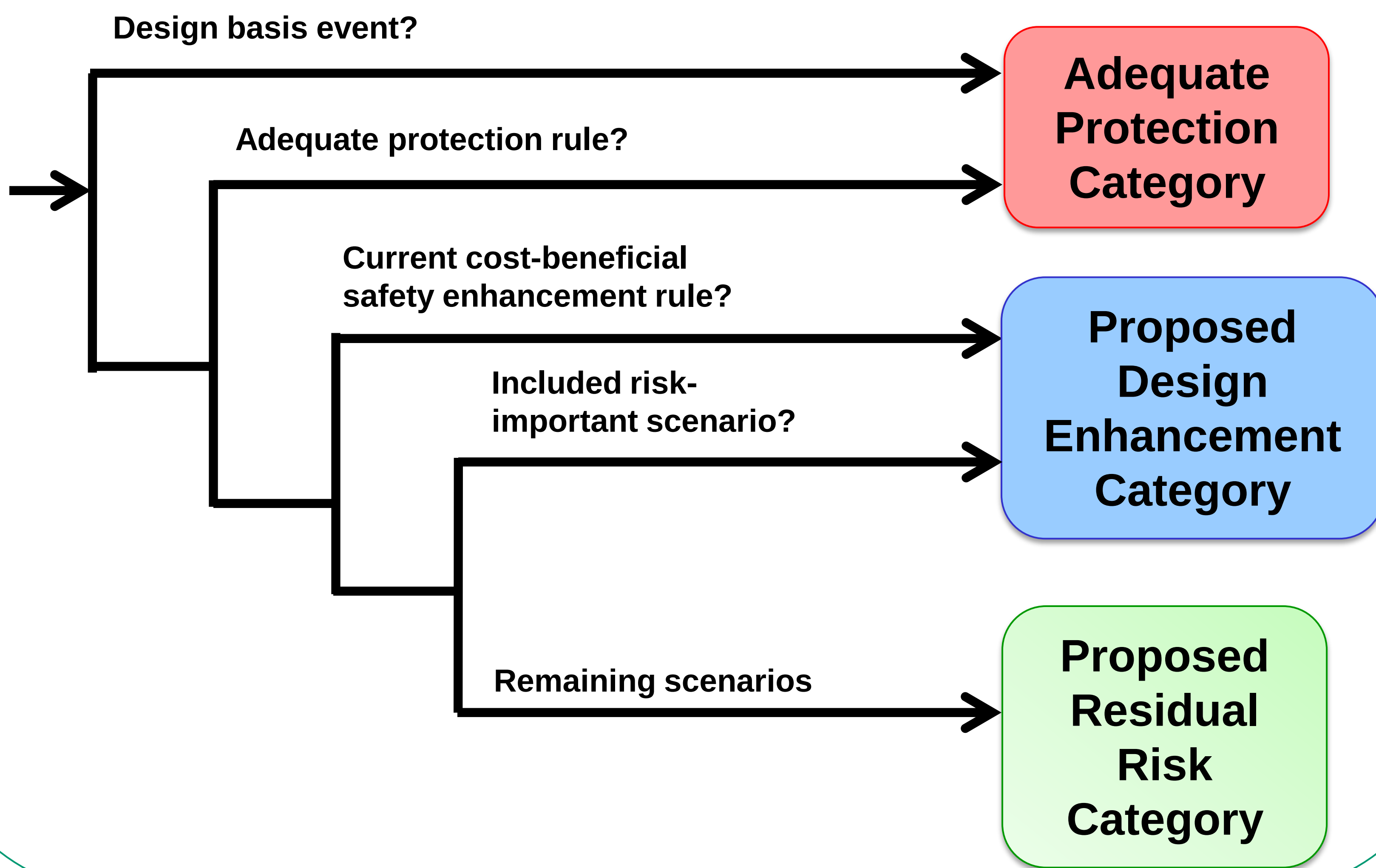


Operating Reactor Recommendations

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

Fuel Cycle Facilities

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<u>Finding F-F-1:</u> The current fuel cycle regulatory approach incorporates several elements of the proposed risk management regulatory framework, such as the use of ISAs to identify safety significant items, and the implementation of a revised fuel cycle oversight program as directed by the Commission.

<u>Finding F-F-2:</u> The concept of defense in depth, as embedded in fuel cycle regulatory requirements and practices, is consistent with Commission guidance. Its implementation changes as the processes change at the fuel cycle facilities.

<u>Recommendation F-R-1:</u> The fuel cycle regulatory program should continue to evaluate the risk and the associated defense-in-depth protection by using insights gained from ISAs. ISAs should continue to evolve to support regulatory decisionmaking.

Acronyms

- **ALARA – as low as reasonably achievable**
- **ATWS – anticipated transient without scram**
- **CDF – core damage frequency**
- **ISA – integrated safety analysis**
- **ISFSI – independent spent fuel storage installation**
- **LERF – large early release frequency**
- **NRC – Nuclear Regulatory Commission**
- **PRA – probabilistic risk assessment**
- **QHO – quantitative health objective**
- **RMTF – Risk Management Task Force**
- **SBO – station blackout**
- **SOARCA – State-of-the-Art Reactor Consequence Analysis**