Safety Risk Metrics

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PRA Model Overview

Level I   **Level II**   **Level III**

| PLANT MODEL | → | CONTAINMENT MODEL | → | SITE/CONSEQUENCE MODEL |

Accident Initiators

Results

Accident sequences leading to plant damage states

Results

Containment failure/release sequences

PLANT MODE
At-power Operation
Shutdown / Transition Evolutions

Results

Public health effects

SCOPE
Internal Events
External Events

History and Questions

- The first PRA was NRC-sponsored and was issued in 1975.

- The industry started doing PRAs in the late 70s.

- Very low frequencies were reported, e.g., 10^{-5} per reactor year.

- Are these numbers tolerable ("acceptable")?

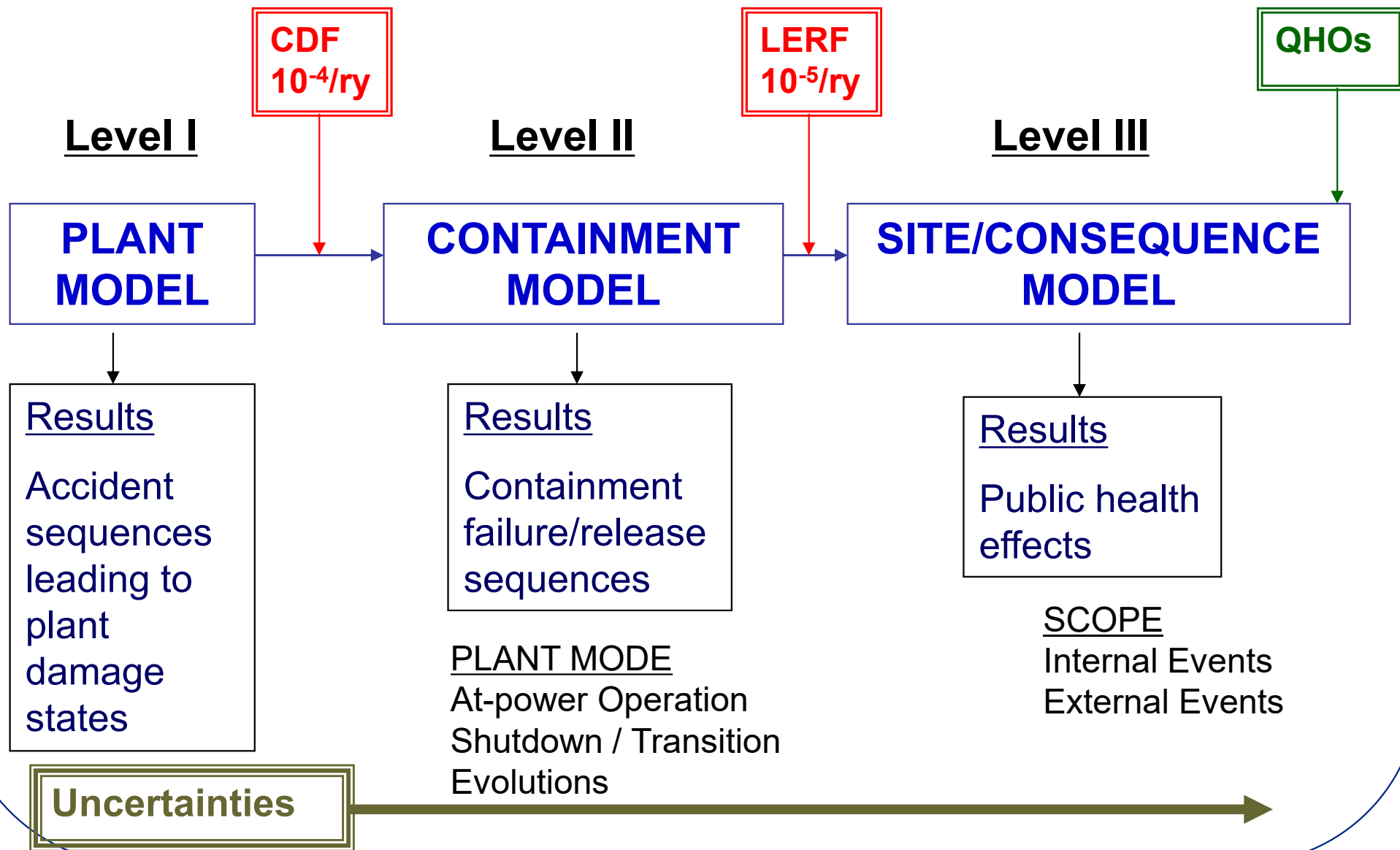- How can they be used in decision making?

U.S. Nuclear Regulatory Commission (August, 1986)

Quantitative Health Objective (QHOs)

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 x 10^{-7}/year for early death and 2 x 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.

PRA Model Overview and Subsidiary Objectives

CDF
10^{-4}/ry

LERF
10^{-5}/ry

QHOs

Level I

Level II

Level III

PLANT MODEL

CONTAINMENT MODEL

SITE/CONSEQUENCE MODEL

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Uncertainties

Decision Making

- **Risk-informed decision making (RIDM):**
  - ➤ **PRA results are one input to a subjective decision-making process that includes elements of traditional engineering approaches such as defense in depth.**
    NRC Regulatory Guide 1.174.

- **The subsidiary goals (CDF and LERF) are used routinely in RIDM.**

My View on QHOs

- For many years, the QHOs were applied to single units.

- Fukushima demonstrated that multi-unit accidents are important.

- Should the QHOs continue to apply to single units?

- My answer: No. They should apply to the sites.

- Is security separate?

- My answer: No. The QHOs should include the risk contribution of malicious acts.

- The QHOs can be viewed as a contract between the nuclear enterprise and society. We cannot revise them every time we find new failure modes.

Our Challenge

- **How can malicious acts be incorporated in the structure of the PRA?**

- **What are their probabilities?**

- **In a traditional PRA, the probabilities are the product of evidence and expert judgment.**

- **Can we use the same approach in security?**

- **If so, what is the evidence and who are the experts?**