Risk-Informed Decision Making: Benefits and Obstacles

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What is it?

- An approach to regulatory decisionmaking, in which insights from probabilistic risk assessment are considered with other engineering insights.

- Definition of risk (Kaplan-Garrick triplet)
  - What can go wrong?
  - How likely is it?
  - What would be the consequences?

- The NRC then uses risk information to reduce the probability of an accident and to mitigate its consequences.

NRC Glossary

Traditional Regulatory Approach

- Management of uncertainty (unquantified at the time) was always a concern

- Defense-in-depth and safety margins became embedded in the regulations

- Design Basis Accidents (DBAs)
  - Postulated accidents that a facility is designed and built to withstand without exceeding the offsite exposure guidelines of the siting regulations
  - They are very unlikely events

Problems with the Traditional Approach

- There is no guidance as to how much defense in depth is sufficient
- DBAs use qualitative approaches for ensuring system reliability (the single-failure criterion) when more modern quantitative approaches exist
- DBAs do not reflect operating experience and modern understanding
- The significance of human errors and support systems is not appreciated
- Multiunit safety analysis would be very difficult to do.

PRA Model Overview and U.S. Subsidiary Objectives

CDF
10^{-4}/year

LERF
10^{-5}/year

QHOs

Level I

Level II

Level III

PLANT MODEL

- *Results:* Accident sequences leading to plant damage states; core damage frequency

CONTAINMENT MODEL

- *Results:* Containment failure/release consequences
- *Plant Mode:*
  - At-power Operation
  - Low-power Operation

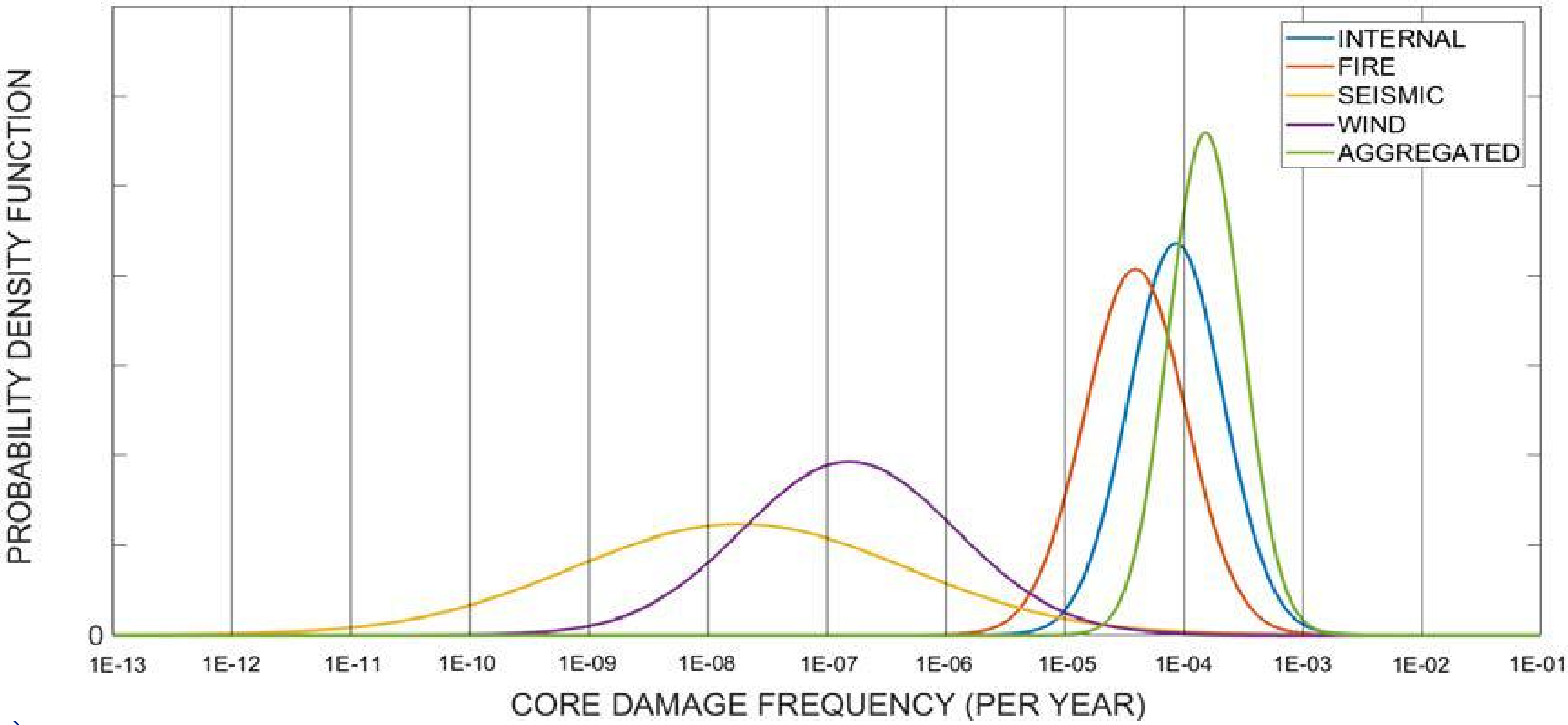
SITE/CONSEQUENCE MODEL

- *Results:* Public health effects
- *Scope:*
  - Internal Events
  - External Events

Uncertainties

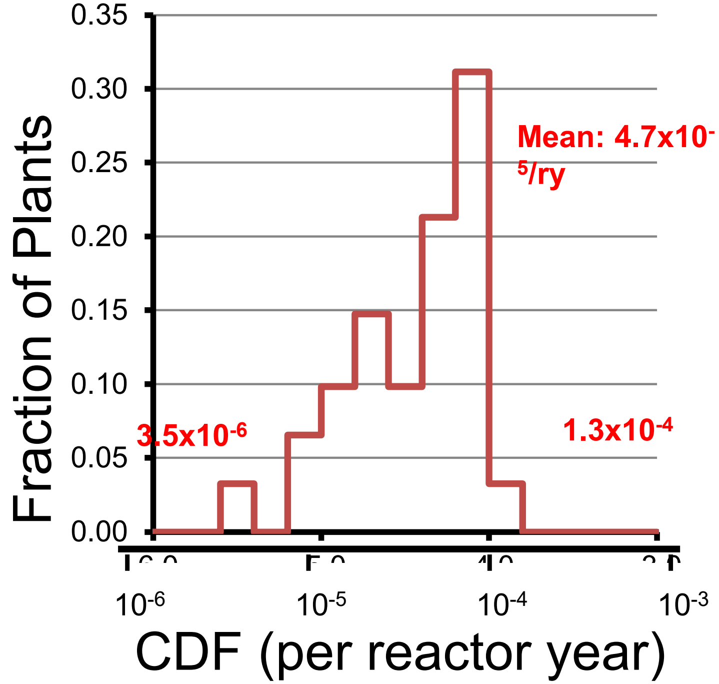
Uncertainties

- Uncertainties exist in traditional deterministic approaches also. PRA quantifies them explicitly
- For this plant, the seismic contribution is very uncertain, yet it does not contribute much to the overall CDF



PRA CDF Estimates for U.S. Plants*

- Current point estimates including internal and external events (61 units)
    - Post 2000 (90% after 2005)
- These plants were licensed under the same deterministic rules
- Plant-to-plant variability reflects differences in designs and modeling



*From License Amendment Requests (LAR) and Severe Accident Management Alternative (SAMA) analyses

PRA Standards

- "The peer review is to be performed against established standards" (RG 1.200)
- Examples
  - ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008 Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications,"
  - ASME/ANS RA-S-1.4-2013: Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants (for trial use)
- Concern about stifling methodological progress

Risk-Informed Framework

Traditional "Deterministic" Approach

- Unquantified probabilities
- Design-basis accidents
- Defense in depth and safety margins
- 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

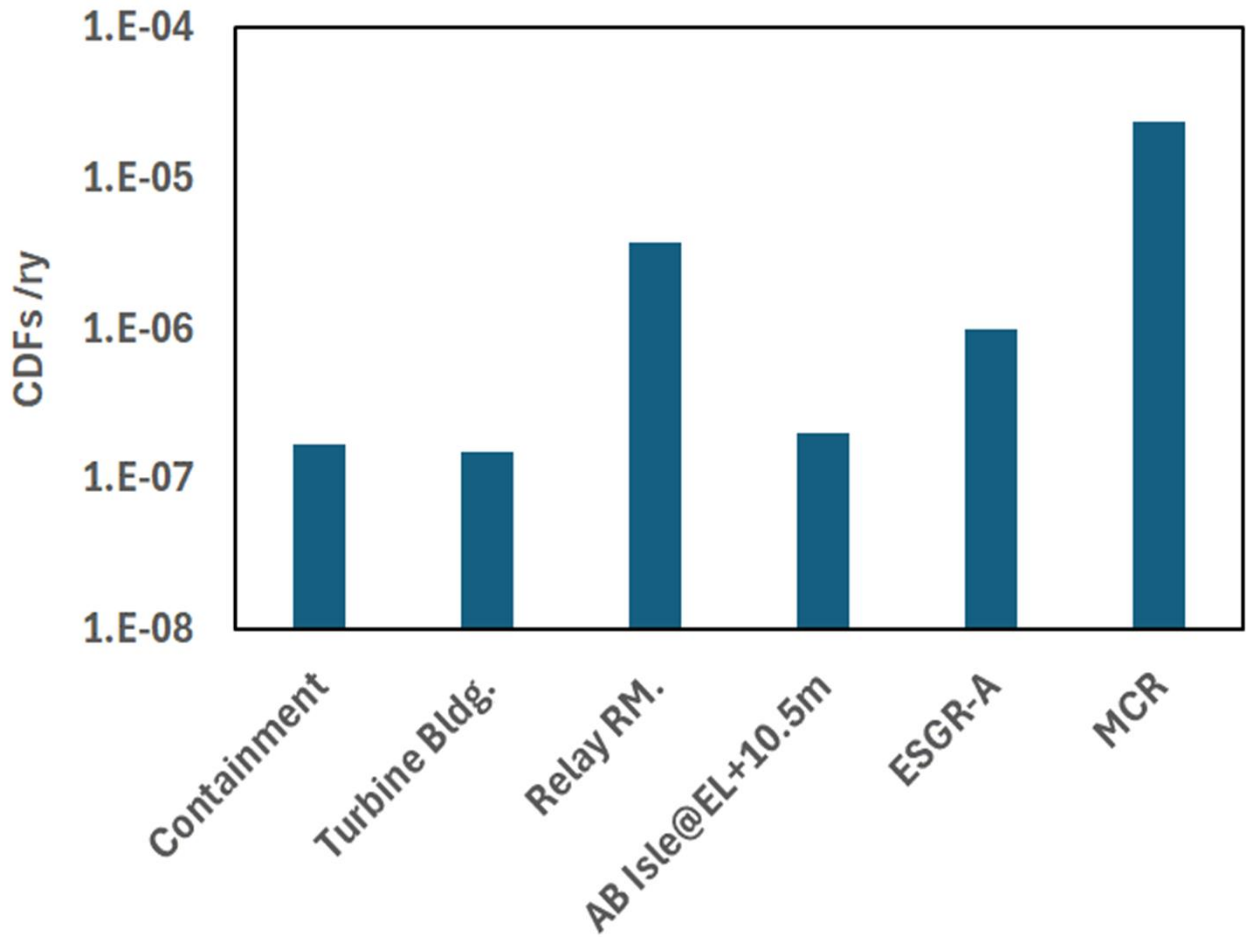
Obstacles in Japan

- **PRA quality is questionable**
  - **Typically, the CDF is in the neighborhood of 10^{-6} per year.**
- **Industry Response**
  - **NRRC's Technical Advisory Committee (TAC) high-level review of Ikata 3 PRA**
  - **International PRA review teams reviewed and made recommendations for improvement to the Ikata 3 (PWR) and Kashiwazaki-Kariwa (BWR) PRAs.**
  - **The ASME/ANS Level 1 PRA Standard and the ASME/ANS Level 2 PRA Standard were used.**
  - **"Although there are opportunities for improvement, the PRA has been developed in a manner generally consistent with good international practices"** *KK7 Review Team*
  - **Other plants will upgrade their PRAs consistent with the findings for the reviewed PRAs.**

The 10^{-6} Culture

- A recent NRRC study showed that the contribution from fires led to a CDF greater than 10^{-5} (next slide).
- Unexpectedly, some utility engineers were concerned that this number was "too high" and might create a regulatory issue.
- Such a number is not too high and is consistent with international practice.
- This incident shows there is a need for regulatory performance metrics.
- "Informal" Performance Metrics in Japan
  - CDF < 10^{-4} per reactor year
  - Containment Failure Frequency (CFF) < 10^{-5} per ry
  - Frequency of release of more than 100 TBq of Cs 137< 10^{-6} per reactor year

Recent Results on Fires



From: Uchida, Shirai, Suzuki, Nonose, Ji, "Fire PRA for a Model Plant at NRRC," Presented at PSAM 17-ASRAM 2024.

Summary

- Uncertainties have always been of concern in regulatory decision making
- Both traditional and risk-informed approaches manage risk
  - Traditional methods manage uncertainties through conservatism, defense in depth, and safety margins; uncertainties are not quantified
  - Risk assessment provides a global view of accident sequences, quantifies uncertainties, and is more realistic
- Risk-informed decision making combines the best features of both approaches
- Plant-specific PRAs provide a picture of the risk profile of individual plants
- Peer reviews using accepted standards are the way to ensure high-quality PRAs.
- Formal performance metrics