What is RIDM?

Lecture 1-1

The NRC’s policy statement on probabilistic risk assessment (PRA) encourages greater use of this analysis technique to improve safety decisionmaking and improve regulatory efficiency. The NRC staff’s PRA Implementation Plan describes activities now under way or planned to expand this use. These activities include, for example, providing guidance for NRC inspectors on focusing inspection resources on risk-important equipment, as well as reassessing plants with relatively high core damage frequencies for possible backfits.

Another activity under way in response to the policy statement is using PRA to support decisions to modify an individual plant’s licensing basis (LB). This regulatory guide provides guidance on the use of PRA findings.
Key Topics

- Practical purpose of risk assessment
- Triplet definition of risk
- Difference between risk-informed and risk-based decision making
Resources


An Unexpected Research Result

As part of an international research program, NRC-supported experimentalists intentionally create electrical faults in medium voltage switchgear to determine the potential consequences. The resulting explosions appear to be reasonably consistent with (or even bounded by) current models. Then one day…
HEAF Video

OECD/NEA High Energy Arcing Fault (HEAF) Program Phase 1
Project information: http://www.oecd-nea.org/jointproj/heaf.html
Sample Decision Options

A. Stop the experiments until the relevance to field conditions is confirmed and the regulatory applications are clarified

B. Continue the current experiments while alerting the industry and other stakeholders of preliminary findings

C. Shut down all plants with similar switchgear
Potential Outcomes

- **S**
  - **F_{A1}**: HEAF Accident? No, Power Generation Loss: None, Probability: \( p_{A1} \)
  - **F_{A2}**: HEAF Accident? Yes, Power Generation Loss: Major, Probability: \( p_{A2} \)
  - **F_{B1}**: HEAF Accident? No, Power Generation Loss: Minor, Probability: \( p_{B1} \)
  - **F_{B2}**: HEAF Accident? Yes, Power Generation Loss: Major, Probability: \( p_{B2} \)
  - **F_{C1}**: HEAF Accident? No, Power Generation Loss: Major, Probability: \( p_{C1} \)
  - **F_{C2}**: HEAF Accident? Yes, Power Generation Loss: Major, Probability: \( p_{C2} \)

Notes:
- Outcomes are simplified for illustration
- Probabilities and consequences for Option B depend on industry response to alert
- Probabilities and consequences for Option C recognize possibility of accidents while shutdown

Risk assessment purpose
Observations

- “Worst case” (a HEAF-induced accident and major losses of power) is possible (albeit unlikely) for all three options.

- Selection of the best alternative requires consideration of likelihood and consequence, i.e., risk.

  ⇒ Risk assessment is a useful tool for decision support.

  ⇒ The scope, approach, level of detail, etc. of the risk assessment depend on the needs of the decision problem.

  “Risk assessment is a set of tools, not an end in itself. The limited resources available should be spent to generate information that helps risk managers to choose the best possible course of action among the available options.”

  - National Research Council, 1994
Dictionary Definitions of “Risk”

1. The chance of injury, damage, or loss; a dangerous chance; a hazard.

2. In insurance, (a) the chance of loss; (b) the degree of probability of loss; (c) the amount of possible loss to the insuring company; (d) a person or thing with reference to the risk involved in insuring him or it; (e) the type of loss that a policy offers (e.g., fire risk).

=> Consideration of likelihood OR consequences
Common Scalar Definition

\[ \text{Risk} \equiv \sum_i p_i \times C_i \]

- Includes effects of likelihood and consequences
- Purely quantitative
- Enables simple scalar comparisons
- Average value, equates
  - Low-probability/high-consequence
  - High-probability/low-consequence
Low-Probability/High Consequence vs. High-Probability/Low Consequence

Part 121 Accidents, 2004-2013

National Transportation Safety Board, 2016. (http://www.ntsb.gov/investigations/)

The Farmer Curve

The Triplet Definition of “Risk” (Kaplan and Garrick, 1981)

Risk ≡ \{s_i, C_i, p_i\}

Features

- Vector, not scalar
- Qualitative and quantitative
- Differences across accident spectrum

- What can go wrong?
- What are the consequences?
- How likely is it?
Other Organizational Definitions

• International Atomic Energy Agency (referring to “radiation risks”): “detrimental health effects of radiation exposure (including the likelihood of such effects occurring)” (IAEA SF-1, 2006)

• Department of Homeland Security: “the potential for an adverse outcome assessed as a function of threats, vulnerabilities, and consequences associated with an incident, event, or occurrence” (DHS Risk Lexicon, 2010)

• National Aeronautics and Space Administration: “the potential for performance shortfalls, which may be realized in the future, with respect to achieving explicitly established and stated performance requirements” (NASA/SP-2010-576, 2010)

• Office of Management and Budget: “the effect of uncertainty on objectives” (OMB Circular A-123, 2016)*

*Text generally refers to “risks” as sources of “risk”
Deliberative Decision Making

Decisionmaking Process
Use a disciplined process to achieve the risk management goal:

- Identify issue
- Identify Options
- Analyze
- Implement Decision
- Deliberate
- Monitor
Naturalistic Decision Making

- Recognition-Primed Decision model
  - Pattern recognition
  - Mental simulation
  - Go with first match
  - Continue until change is required
  - Risk consideration: “Will it work?”

- Not limited to field applications

Risk-Based vs Risk-Informed

• Accidents are rare events
  ⇒ Empirical data are sparse
  ⇒ Models play central role

• SECY-98-144: ‘A “risk-informed” approach to regulatory decision-making represents a philosophy whereby risk insights are considered together with other factors to establish requirements that better focus licensee and regulatory attention on design and operational issues commensurate with their importance to public health and safety.’
Allocating Resources: Risk-Based?

U.S. Mortalities (2016)

Or Risk-Informed?

U.S. Mortalities (2016)

- Heart Disease: 23%
- Cancer: 22%
- Other: 26%
- Suicide: 6%
- Kidney Disease: 5%
- Influenza & Pneumonia: 5%
- Diabetes: 4%
- Alzheimer Disease: 5%
- Stroke: 3%
- Accidents: 2%
- Chronic Lower Respiratory Diseases: 2%

“Other Factors” for NPP RIDM

- Defense-in-depth
- Current regulations
- Safety margins
- Monitoring
- Risk

Integrated Decision Making

Adapted from RG 1.174
RIDM Implications for Risk Assessment

• Decision support
  – Use science, but aim is not science
  – Subject to economic and time constraints
    => needs to be “good enough”
    • Decisions can be insensitive to some aspects
    •Bounding analyses can be sufficient
    • Risk is one of a number of inputs to RIDM
  – Need to characterize uncertainties

• Risk considerations
  – Despite best efforts by designers, operators, etc., risk is never zero
    => need to search for scenarios that can challenge assumptions
  – Recognize weaknesses and implicit assumptions in possibilistic/“worst case” approaches
Risk Assessment vs. Risk Management

RESEARCH

- Laboratory and field observations of adverse health effects and exposures to particular agents
- Information on extrapolation methods for high to low dose and animal to human
- Field measurements, estimated exposures, characterization of populations

RISK ASSESSMENT

- Hazard Identification (Does the agent cause the adverse effect?)
- Dose-Response Assessment (What is the relationship between dose and incidence in humans?)
- Exposure Assessment (What exposures are currently experienced or anticipated under different conditions?)

RISK MANAGEMENT

- Development of regulatory options
- Evaluation of public health, economic, social, political consequences of regulatory options
- Risk Characterization (What is the estimated incidence of the adverse effect in a given population?)
- Agency decisions and actions