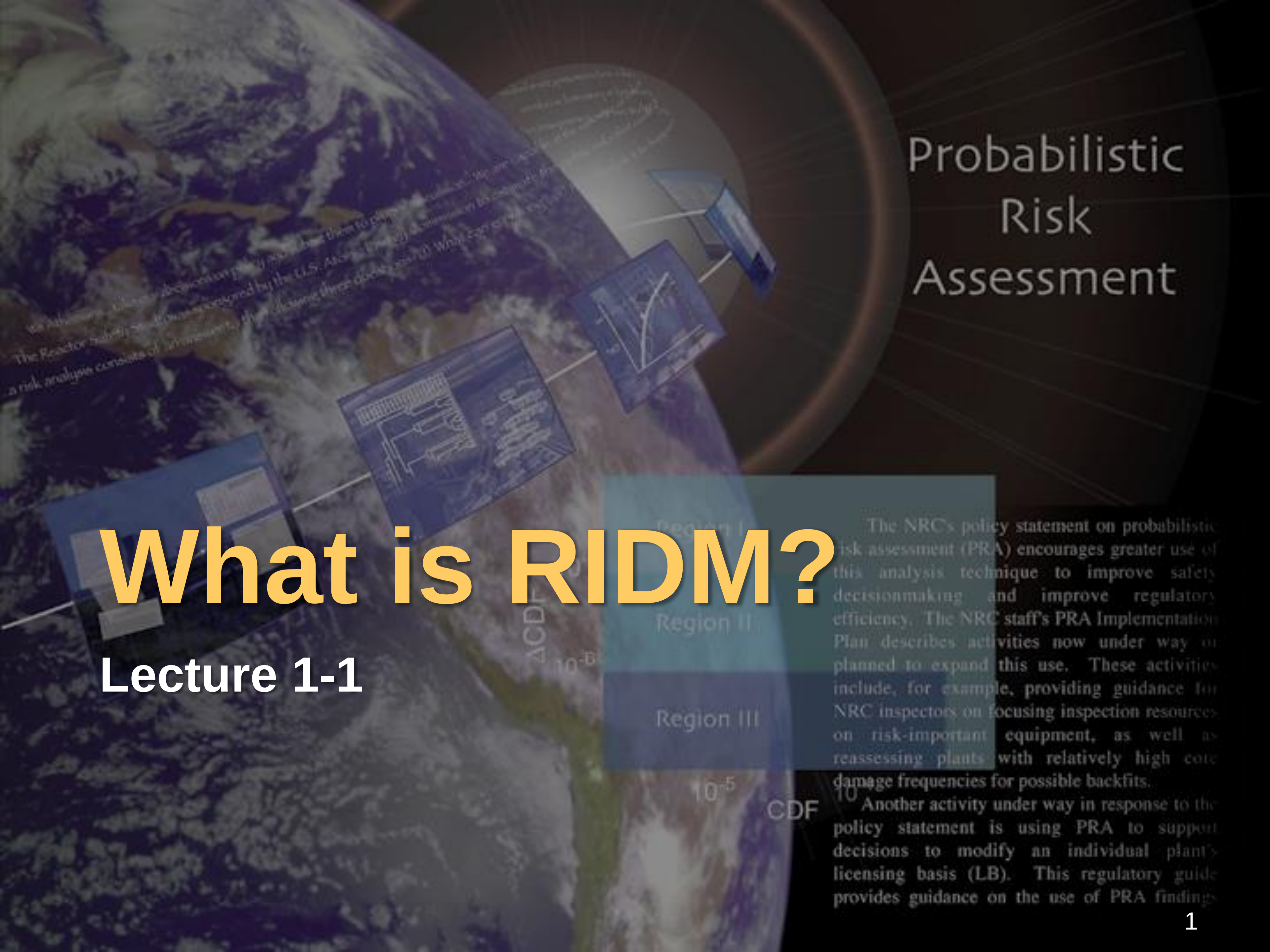

What is RIDM?

Lecture 1-1

Key Topics

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

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Resources

- G. Apostolakis, et al., “A Proposed Risk Management Regulatory Framework,” *NUREG-2150*, U.S. Nuclear Regulatory Commission, April 2012.
- International Nuclear Safety Group, “A Framework for an Integrated Risk Informed Decision Making Process,” *INSAG-25*, International Atomic Energy Agency, 2011.
- National Research Council, “Understanding Risk: Informing Decisions in a Democratic Society,” P.C. Stern and H.V. Fineberg (eds), National Academies Press, 1996.
- U.S. Nuclear Regulatory Commission, “White paper on risk-informed and performance-based regulation,” *SECY-98-144*, June 22, 1998.
- S. Kaplan and B.J. Garrick, “On the quantitative definition of risk,” *Risk Analysis*, **1**, 11–37(1981).
- N. Siu, et al., “Probabilistic Risk Assessment and Regulatory Decisionmaking: Some Frequently Asked Questions,” *NUREG-2201*, U.S. Nuclear Regulatory Commission, September 2016.
- M. Drouin, et al., “Glossary of Risk-Related Terms in Support of Risk-Informed Decisionmaking,” *NUREG-2122*, U.S. Nuclear Regulatory Commission, November 2013.

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…

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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

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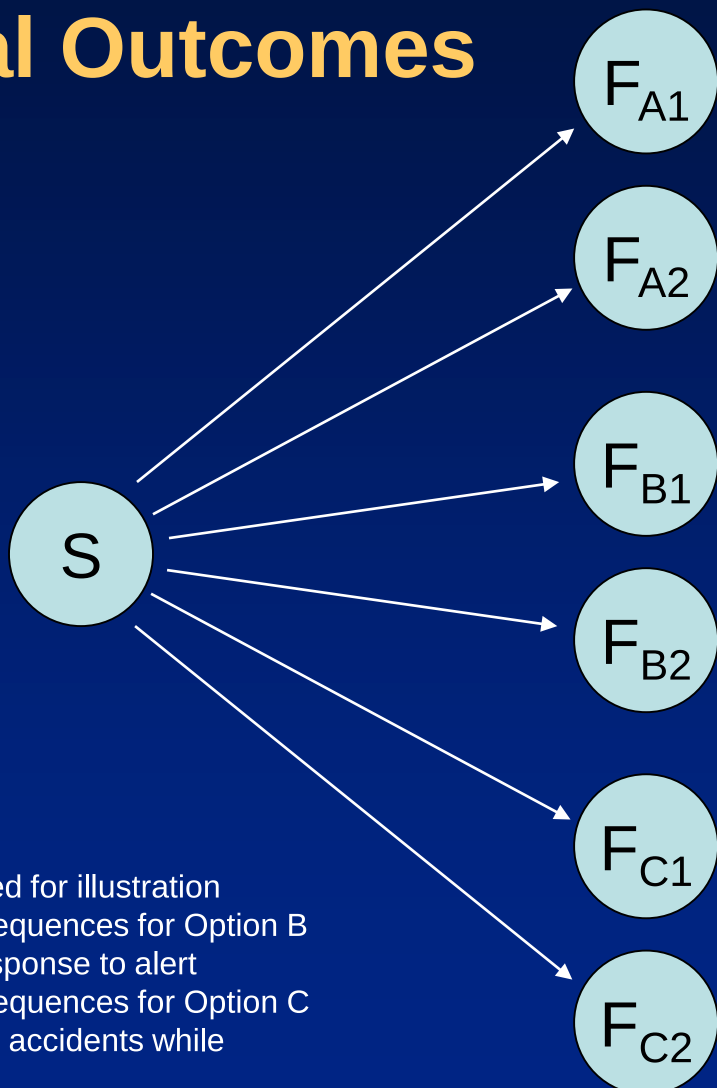
Potential Outcomes



HEAF Accident?	Power Generation Loss	Probability
N	None	p_{A1}
Y	Major	p_{A2}
N	Minor	p_{B1}
Y	Major	p_{B2}
N	Major	p_{C1}
Y	Major	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

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

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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).

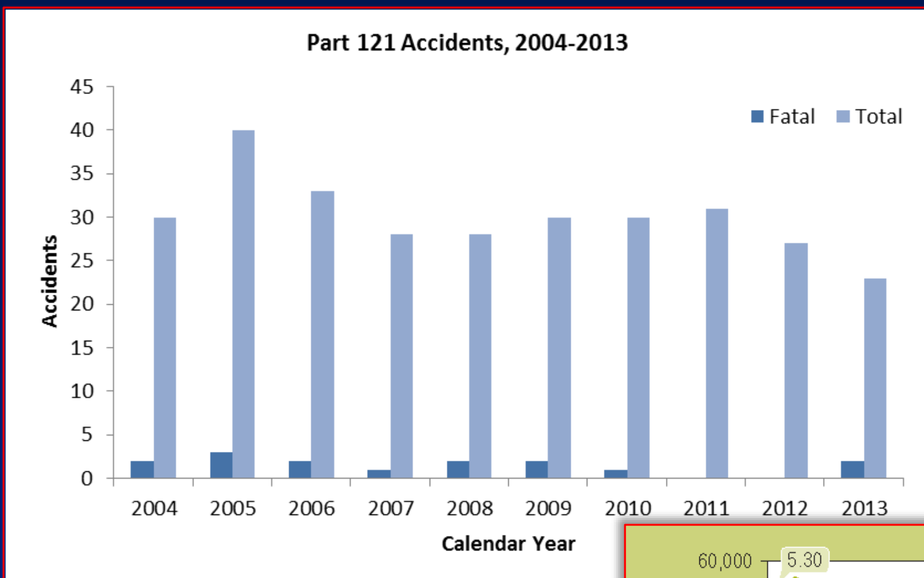
=> Consideration of likelihood OR consequences

Common Scalar Definition

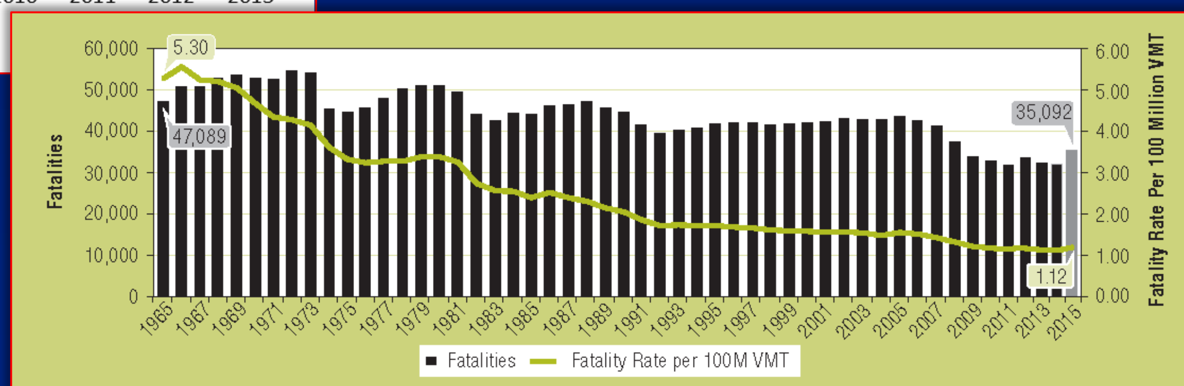
$$\textbf{Risk} \equiv \sum_i p_i \times c_i$$

- 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

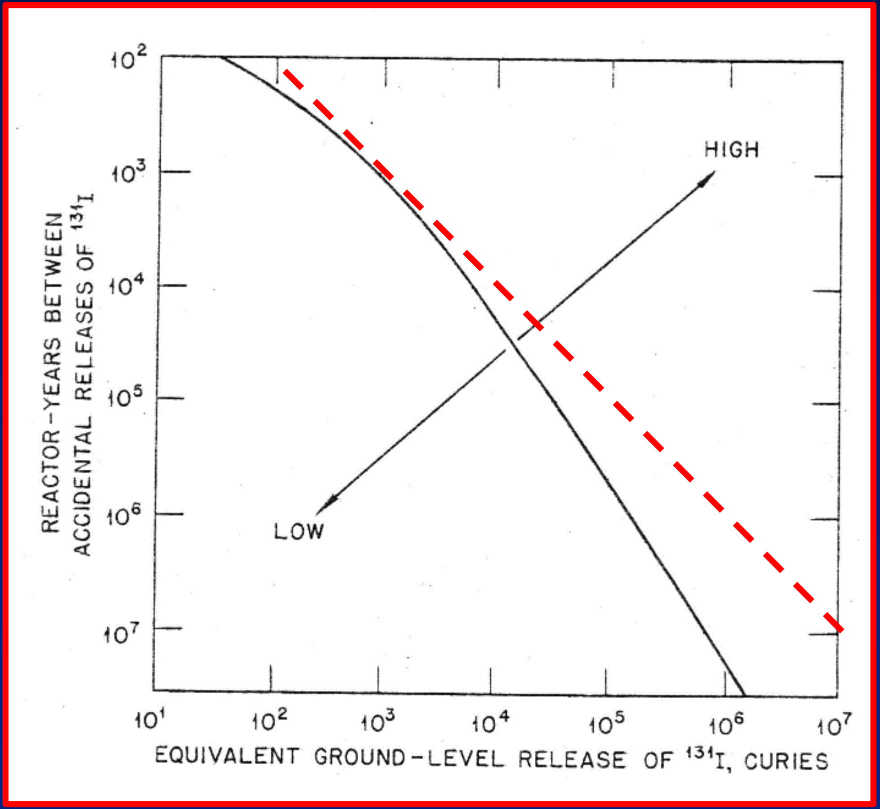


National Transportation Safety Board, 2016. (http://www.ntsb.gov/investigations/)



From "Traffic Safety Facts: Research Note," U.S. Dept. of Transportation, 2016.

The Farmer Curve



Adapted from Farmer, F.R., “Reactor safety and siting: a proposed risk criterion,” *Nuclear Safety*, **8**, 539-548(1967).

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

Risk ≡ $\{s_i, C_i, p_i\}$

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

Features

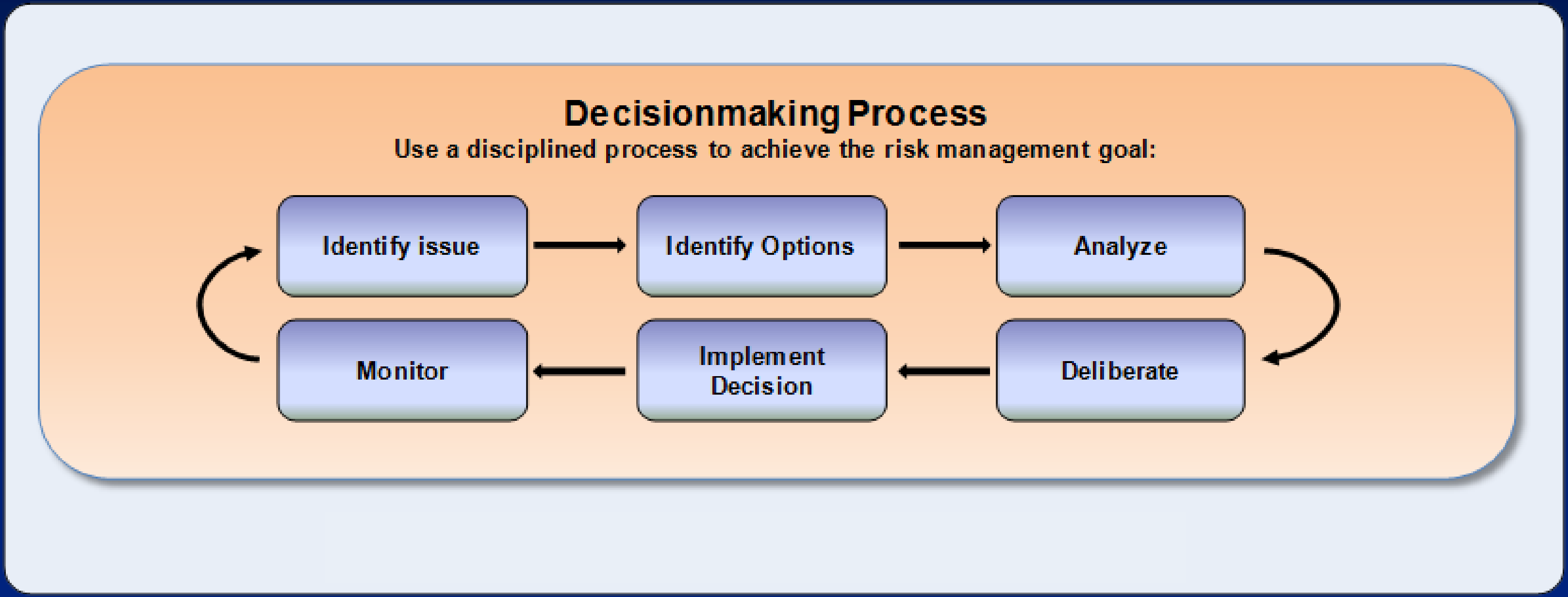
- Vector, not scalar
- Qualitative and quantitative
- Differences across accident spectrum

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



NUREG-2150

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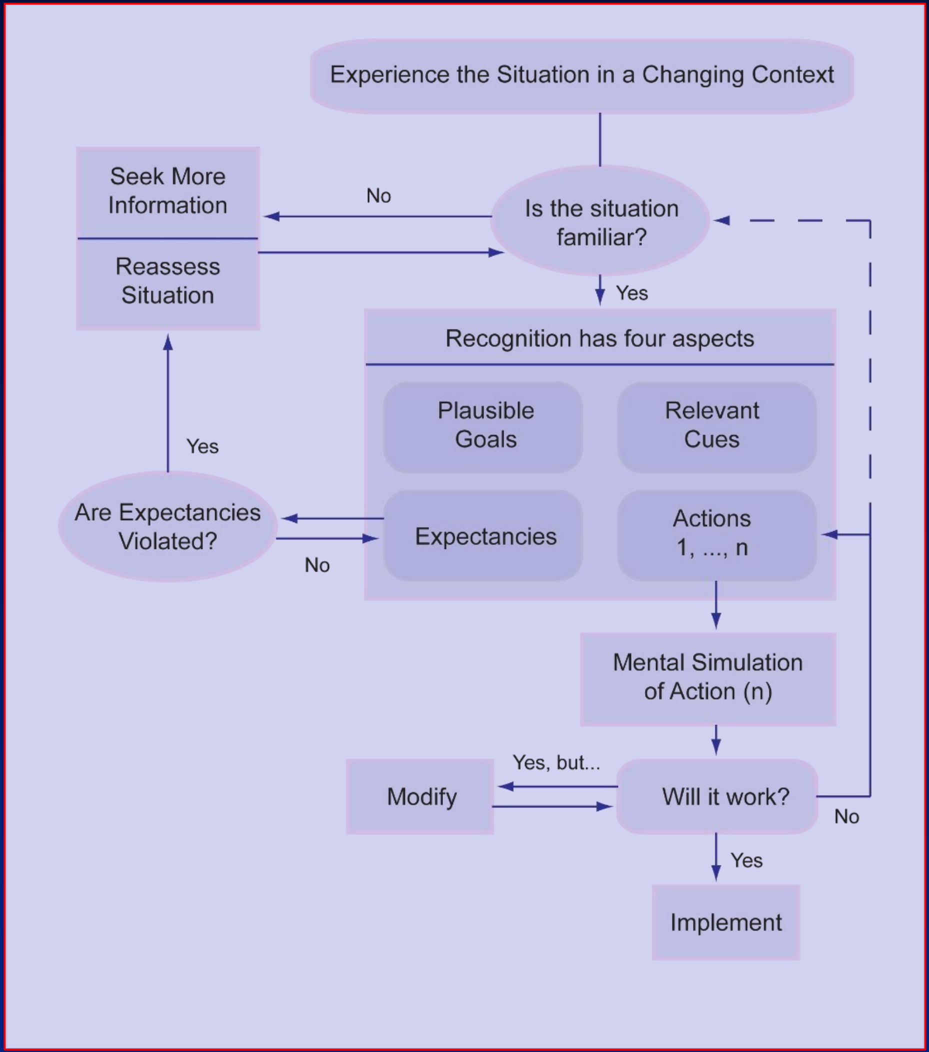
Naturalistic Decision Making

- 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



G.A. Klein, "A recognition-primed decision (RPD) model of rapid decision making," in *Decision Making in Action: Models and Methods*, G.A. Klein, et al., eds. 1993.

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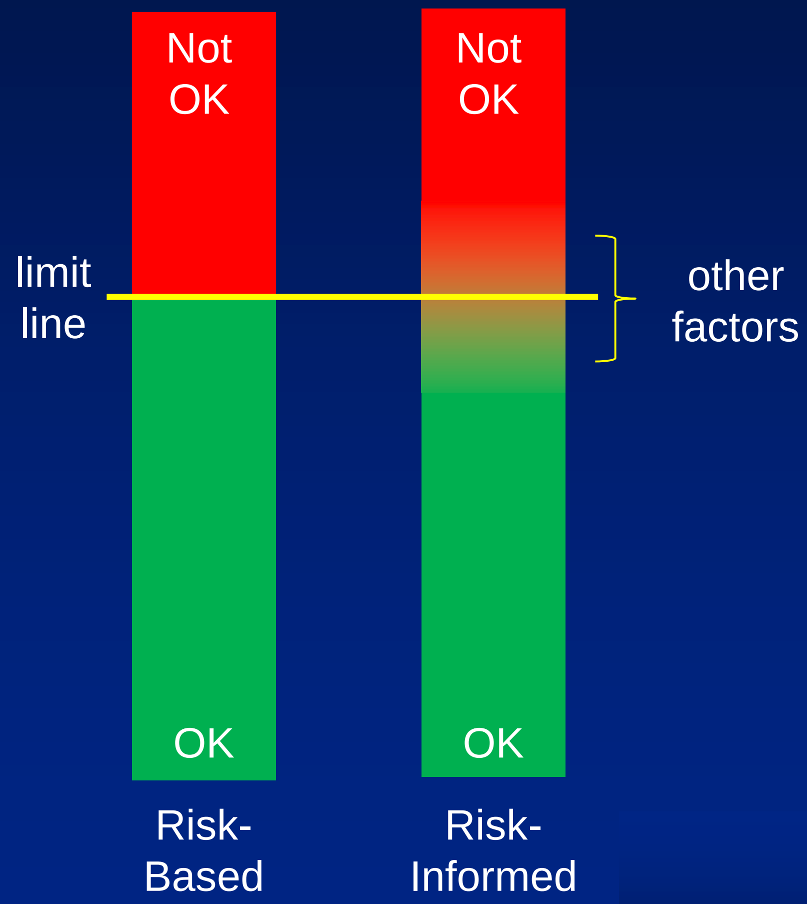
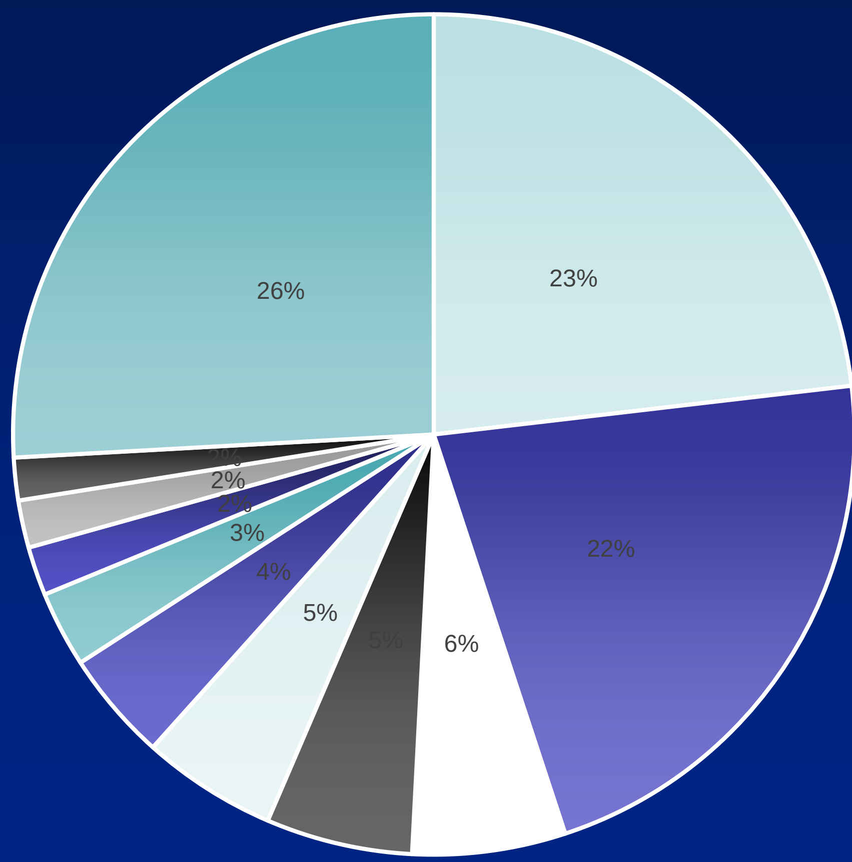
Risk-Based vs Risk-Informed

- 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)



S.L. Murphy, et al., "Mortality in the United States, 2017," NCHS Data Brief, Number 328, November 2018.

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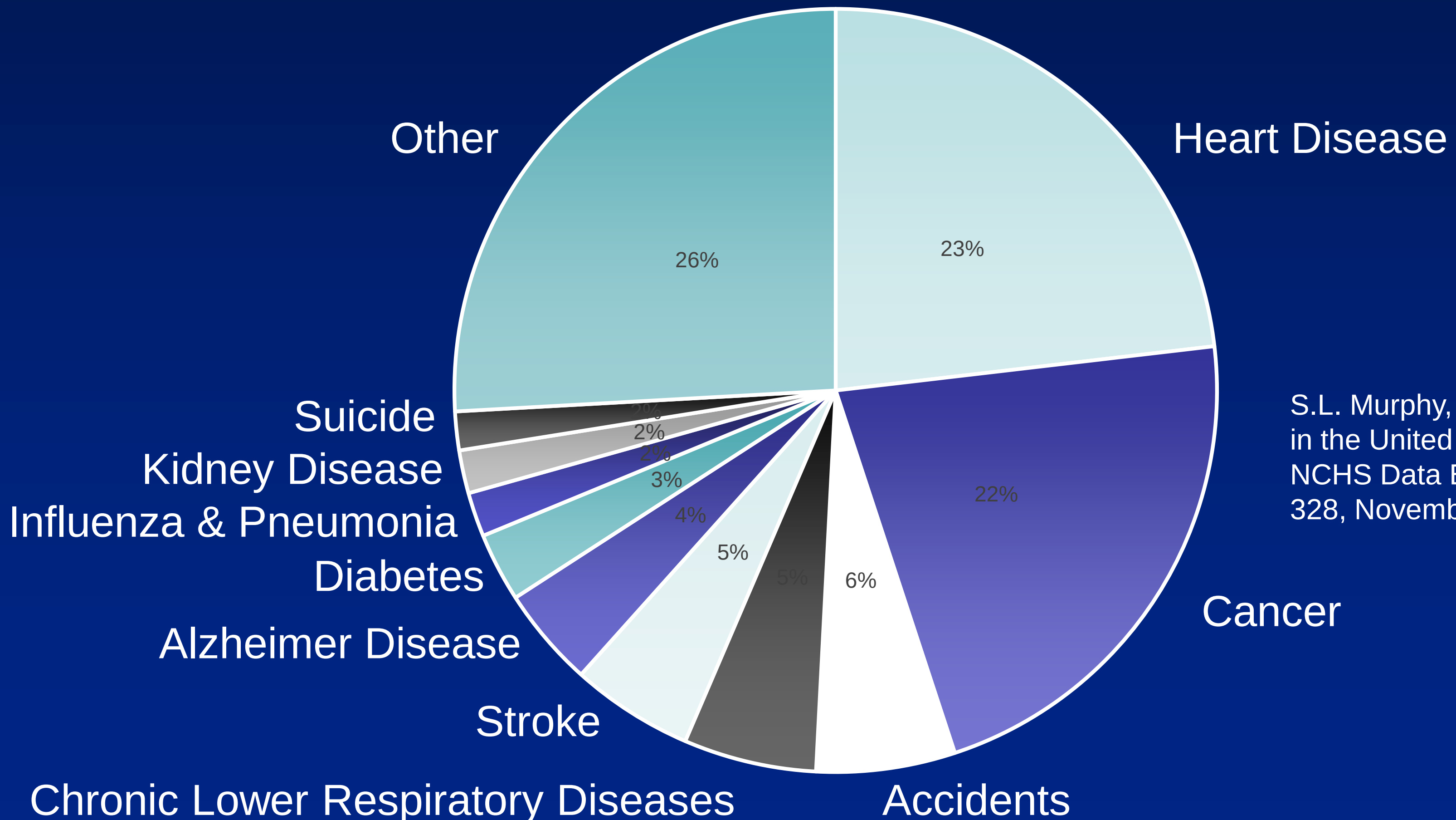
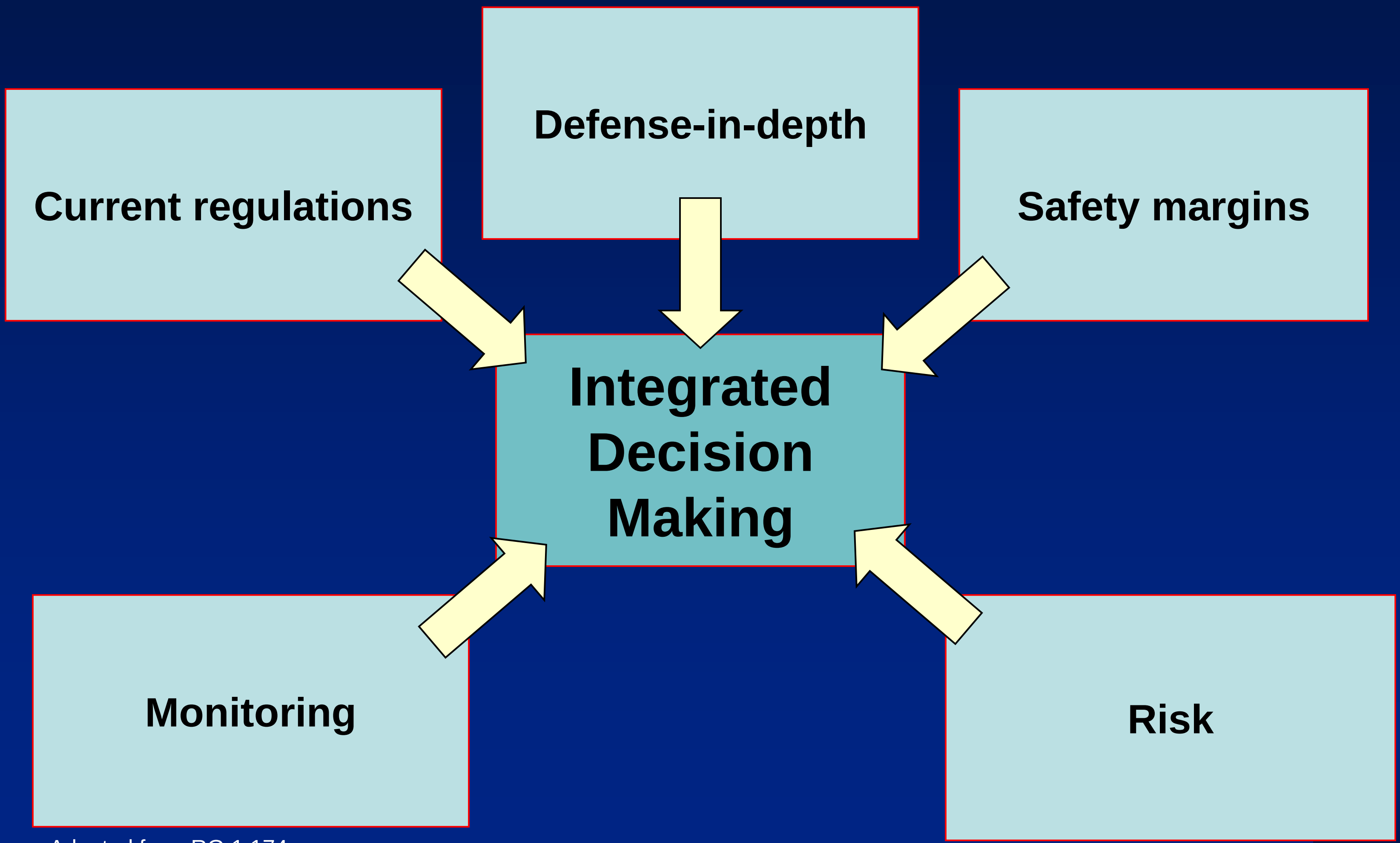
Or Risk-Informed?

U.S. Mortalities (2016)



S.L. Murphy, et al., "Mortality in the United States, 2017," NCHS Data Brief, Number 328, November 2018.

“Other Factors” for NPP RIDM

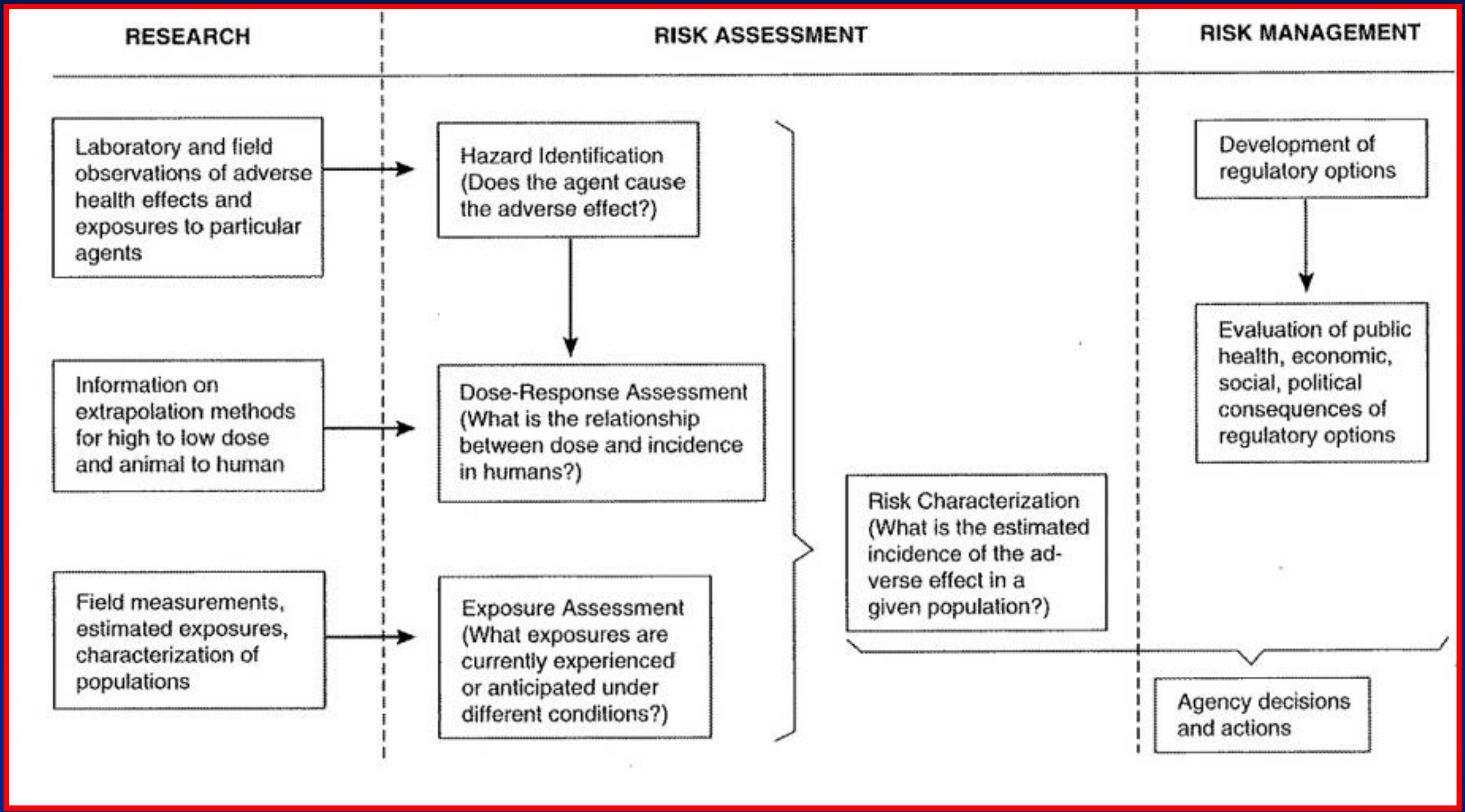


Adapted from RG 1.174

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



National Research Council, “Understanding Risk: Informing Decisions in a Democratic Society,” National Academy Press, 1996.