WMD Terrorism Risk Assessment in the Department of Homeland Security

Joint U.S. EPA and DHS Conference On Real-World Applications and Solutions for Microbial Risk Assessment

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Integrated Chemical Biological Radiological Nuclear iCBRNra Risk Assessment

Why Risk Assessment?

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DHS, HSC Guidance…

"…We need to adopt a risk-based approach in both our operations and our philosophy. Risk management is fundamental to managing the threat… The most effective way to apply risk-based approach is by using the trio of threat, vulnerability and consequence as a general model for assessing risk and deciding on protective measures we undertake."

- Michael Chertoff, Secretary, DHS

"…the United States requires a continuous, formal process for conducting…assessments to guide prioritization of…investments in biodefense-related research, development, planning, and preparedness."

- Biodefense for the 21st Century (HSPD-10)

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DHS, HSC Guidance…(cont'd)

Required by HSPD-18: *Medical Countermeasures against Weapons of Mass Destruction*

§ 14 (c)

"The Secretary of Homeland Security shall develop a strategic, integrated all-CBRN risk assessment… Not later than June 1, 2008, the Secretary of Homeland Security shall submit a report to the President…which shall summarize key findings…and shall update those findings when appropriate, but not less frequently that every 2 years."

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Rare events: Low frequency, High Consequence

- WASH-1400 – 1975: one of the first demonstration of Probabilistic Risk Assessment (PRA) as a method for tackling the probability estimation problem for low-frequency events.
  - Assessed accident risk for nuclear power plants (probability of complete core meltdown assessed at 1 in 20,000 per reactor per year).
- NUREG-1150 – 1991: updated PRA approach based on Three-Mile Island, and improvements in risk assessment research.
- New NRC assessment: will include effect of emergency preparedness and other mitigating factors.
- NASA, Terrorism…

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Probabilistic Risk Assessment

- PRA divides the spectrum of possible events into a discrete set of scenarios. For each scenario, s_i
  - Estimate consequence, C_i
  - Estimate probability, p_i
  - Aggregate the risk from the set of all triplets $\langle s_i, p_i, C_i \rangle$
- Probability estimates are calculated for end-nodes on an ***event tree*** corresponding to specific scenarios. Each distinct path through the tree is a unique scenario.
- Consequence estimates are modeled, given the occurrence of an event tree scenario.

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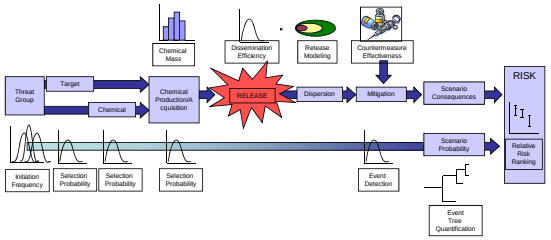
Goal: Modify Established PRA Techniques for Terrorism Risk Assessment



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A dynamic tool, not just a snapshot of risk

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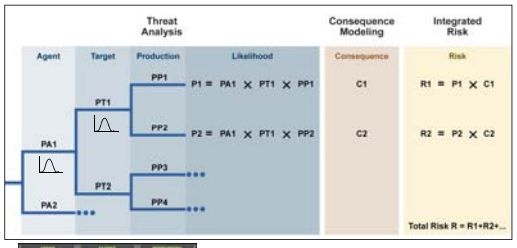
A Simple (Binary) Event Tree



- Ability to adjust parameters to address different questions
- Ability to query system at consequence level of interest

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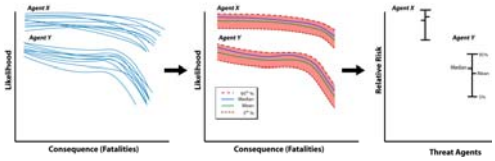
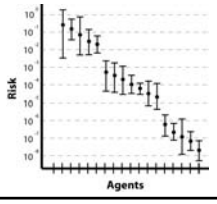
Summarizing the Risk Curves





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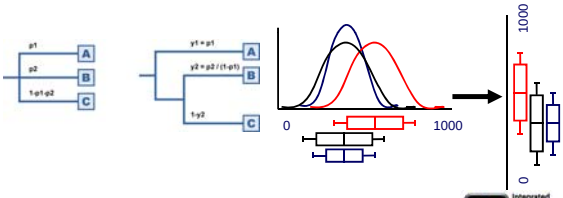
Where do the probabilities in the event tree come from?

- Quantitative data where available
- Expert Judgment (such as Intelligence Community)



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Thoughts on Expert Judgment

- The process of assessing expert judgments provides a snapshot of our current state of knowledge.
- The state of knowledge will be refined as new experiences are gained.
- There is no "right" answer, just good answers

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Thoughts on Expert Judgment

- Expert judgment is pervasive in risk studies. The question is not whether to use expert judgment but whether to use it in an overt manner, documenting its use, or to hide its use.
- Making judgments quantitative (but not implying *certainty*) allows them to be combined with other sources of information and to be manipulated in models.
- Verbal or qualitative assessments lack a common basis for interpretation – we'll see an intelligence example of this shortly.

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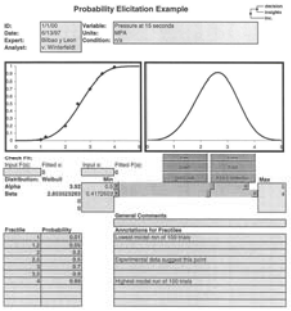
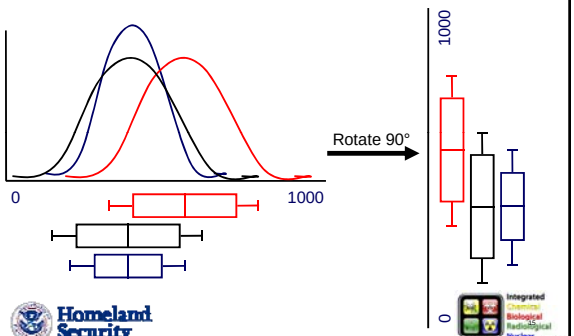
DHS RA Probability Elicitation – NUREG 1150 Protocol

- **Identify issues and select experts**
- **First Meeting:**
  - Discuss issues, share knowledge
  - Define variables and events – "elicitation statement"
  - Probability Training
  - Practice
- **Study period (a few weeks)**
- **Second Meeting:**
  - Review findings, share knowledge
  - Individual elicitations
  - Review and reconciliation
- **Aggregation and documentation**
  - Aggregate expert judgments
  - Document substantive reasoning
  - Document probability reasoning

Elicitation Tools



Multiple Distributions/boxplots: This is the form of most of the elicited information



Extensive use of Elicitation-based PRA Probabilities

- Nuclear Regulatory Commission
- Department of Energy
- Environmental Protection Agency
- Department of Defense
- NASA
  - 1967 Apollo flight loss – spawned one of the earliest comprehensive studies
  - 1969 Goal: Probability of loss of life < 1% (space shuttle task group)
  - 1983 probabilistic risk analysis of shuttle flights
    - NASA administrators quickly abandoned PRA
    - Later events proved accuracy of analysis
  - Common practice (Pate-Cornell and Fischbeck)
- Intelligence Community

Sherman Kent and the Board of National Estimates: Collected Essays. *Center for the Study of Intelligence, CIA (1994)*

100% Certainty

The General Area of Possibility

93%, give or take about 6% — Almost certain

75%, give or take about 12% — Probable

50%, give or take about 10% — Chances about even

30%, give or take about 10% — Probably not

7%, give or take about 5% — Almost certainly not

0% Impossibility

Sherman Kent and the Board of National Estimates: Collected Essays. *Center for the Study of Intelligence, CIA (1994)*

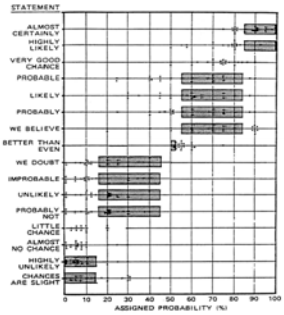


Figure 4.1. Relation between probabilities and verbal expressions. The shaded areas indicate Kent's (1964) proposal for matching words and probabilities. (Reprinted with permission of Decisions and Designs, Inc., from Barclay, Brown, Kelly, Peterson, Phillips, & Selvidge, 1977.)

Summarizing the elicitation process

- **Solid first-principles approach**
  - Backed by 40 years of experience in fields of comparable uncertainty
  - Backed by the National Academies and some of the nation's best minds in probability and decision analysis
  - Used in government for immediate life-and-death analyses (space shuttle, nuclear power plants, etc.)
- **The experts drive the train**
  - Review meetings are an essential component of the process.
  - Experts will review and approve elicited data as a group. Additional understanding gained by the discussions can be a justification for adjusting probabilities.
- **Numbers are important** for a common basis of understanding and comparison.
- **…But quantification does not mean certainty.** Rather, quantification allows experts to more clearly indicate how uncertain they are about an issue or topic.
- **Capturing uncertainty is critical**, and this process is designed to do that in a consistent and appropriate manner
  - Eliciting ranges, not only averages
  - Means and medians are never reported on their own – uncertainty is always attached.

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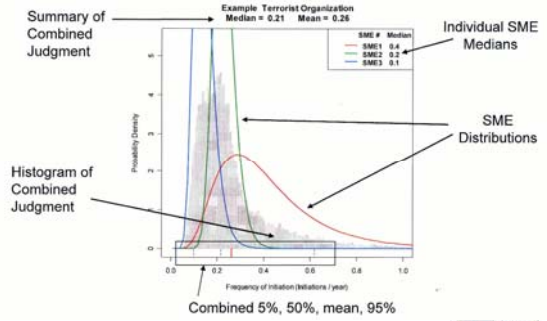
Example Elicited Frequency Distributions



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Data randomly generated – not actual elicitation data

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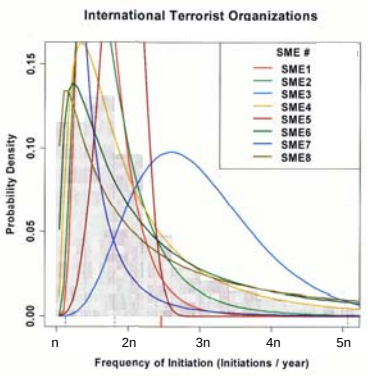

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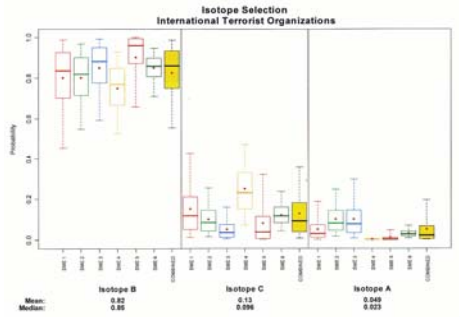
Split Fractions – Adversary Agent Preferences



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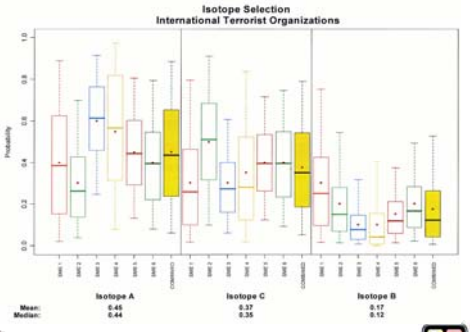

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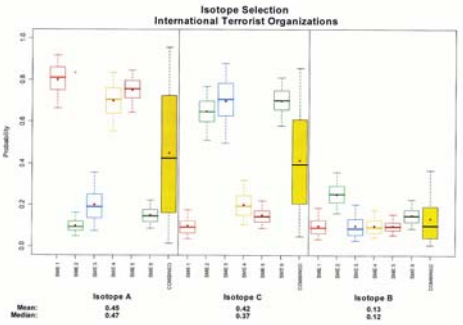

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