



Experiences with Risk Analysis and Implications for Bioterrorism

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Risk Analysis: Over 30 Years of Experience

- Reliability engineering (aerospace industry)
- Nuclear power plant risks
- Chemical and other industrial risks
- Environmental risks
- Natural disaster risks
- Business, project and R&D risks
- Medical risks

CREATE Researchers' Past Experiences

- **Vickie Bier:** Industrial risks, nuclear power plants
- **Richard John:** Earthquakes, dams, nuclear power plants
- **Steve Hora:** Nuclear Waste, nuclear power plants
- **Don Kleinmuntz:** Business and R&D
- **Naj Meshkati:** Industrial safety, human reliability
- **Sheldon Ross:** Engineered systems, network reliability
- **V. Kerry Smith:** Hurricanes, environment
- **Henry Willis:** Infrastructure, defense systems
- **Detlof von Winterfeldt:** Nuclear waste, EMF, earthquakes
- **Rae Zimmerman:** Infrastructure, environment

Terrorism Risk Analysis

Threat Analysis

Probability of
an Attack
 $p(A_i)$



Vulnerability Analysis

Probability of
Success, Given
an Attack
 $q(S_j|A_i)$



Consequence Analysis

Probability of
Damages and
Consequences
 $f(C|A_i, S_j)$



Attempts to Apply Risk Analysis to Terrorism

- Probabilistic risk analysis
 - Dynamic adaptive decision tree analysis
 - Game theory
 - Vulnerability and risk scoring systems
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Hardest Part: Threat Analysis

CREATE Support for NBACC

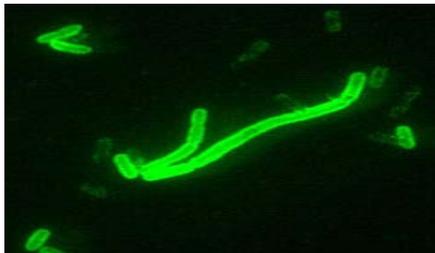
- Probability elicitation training
 - Educate and train NBACC staff and contractors in probability elicitation
 - Conduct selected non-classified elicitations
- Economic impact assessment
 - Several prototype assessments
 - Training NBACC contractors to conduct remaining assessments

Bioterrorism: Assessing the Risks



Bacillus Anthracis (Anthrax):

- Communicable
- Impact Quantity: 100 kilogram fatal to 3 million persons
- Mortality Rate: 25% to 60%



Yersinia pestis (Plague):

- Communicable
- Impact Quantity: 1 infected person creates 10 new cases
- Mortality Rate: 15% to 60%



Raciness communis (Ricin):

- Non-Communicable
- Impact Quantity: 1 milligram can kill an adult
- Mortality Rate: 50% to 85%

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



Bioterrorism Risk Analysis: Front-end Challenges

- 30+ biological agents and four terrorist groups
- Requires understanding of
 - Terrorist motivations and intent (social scientists)
 - Evidence of capabilities and past attempts (Intelligence community)
- Very little data
- Possibly preconceived ideas by experts
 - Availability bias
 - Overconfidence



Expert Elicitation

- Elicitation of selection probabilities of 28 agents
- Four bioterrorism experts
- Two risk analysts (Hora, von Winterfeldt)
- Hierarchical elicitation
- Software support

Formal Expert Elicitation 1

Relative Probabilities (RP) of Attacks by Agents (Given a Bioterrorism Attack - Hypothetical Expert)	
Hi Lethal - Communicable	RP
Yersinia pestis *	20.0%
Variola Major Virus	3.0%
Ebola	0.4%
Lassa	0.1%
Marburg	0.1%
Hi Lethal- Non Communicable	
Bacillus anthracis *	55.0%
Clostridium botulinum *	10.0%
Ricinus communis (castor bean)	6.0%
Burkholderia mallei	0.3%
Nipah virus	0.1%
Bovine Spongiform Encephalopathy *	0.7%
Vibrio cholerae **	5.0%
Other Agents	4.0%

Formal Expert Elicitation 2

Relative Probabilities (RP) of Selected Agents (Given a Bioterrorism Attack - Hypothetical Expert)	
Hi Lethal - Comm	RP
Yersinia pestis *	13%
Variola Major Virus	1%
Ebola	6%
Lassa	6%
Marburg	6%
Hi Lethal- Non Comm	
Bacillus anthracis *	25%
Clostridium botulinum *	13%
Ricinus communis (castor bean)	13%
Burkholderia mallei	1%
Nipah virus	1%
Bovine Spongiform Encephalopathy *	1%
Vibrio cholerae **	3%
Other Agents	9%

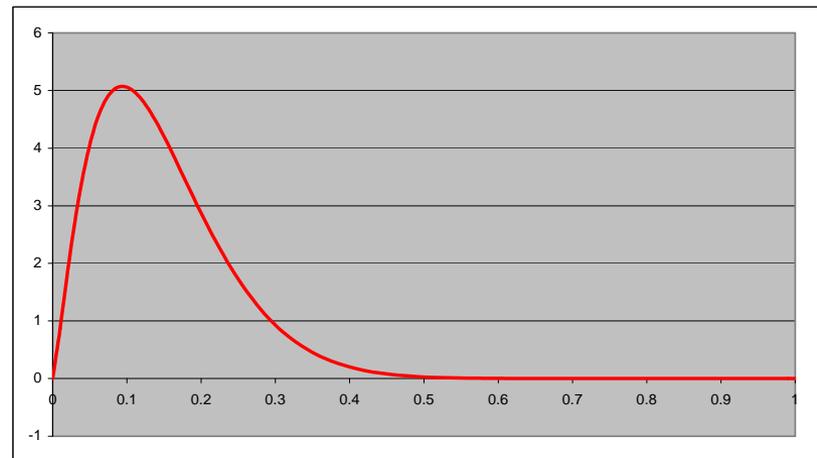
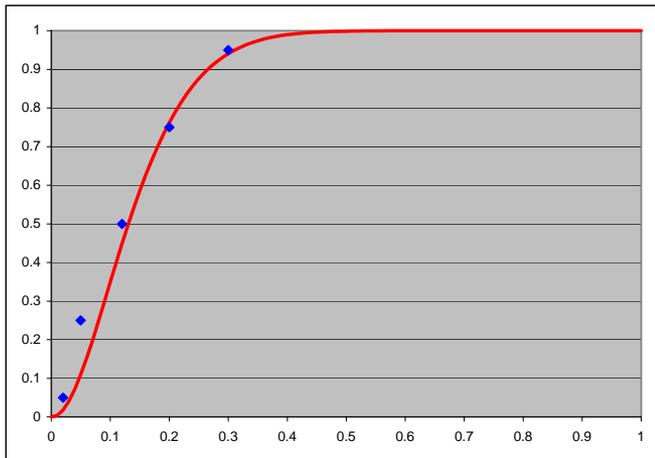
Probability Elicitation Tool: Marginal Betas

Fractiles (input x values below)

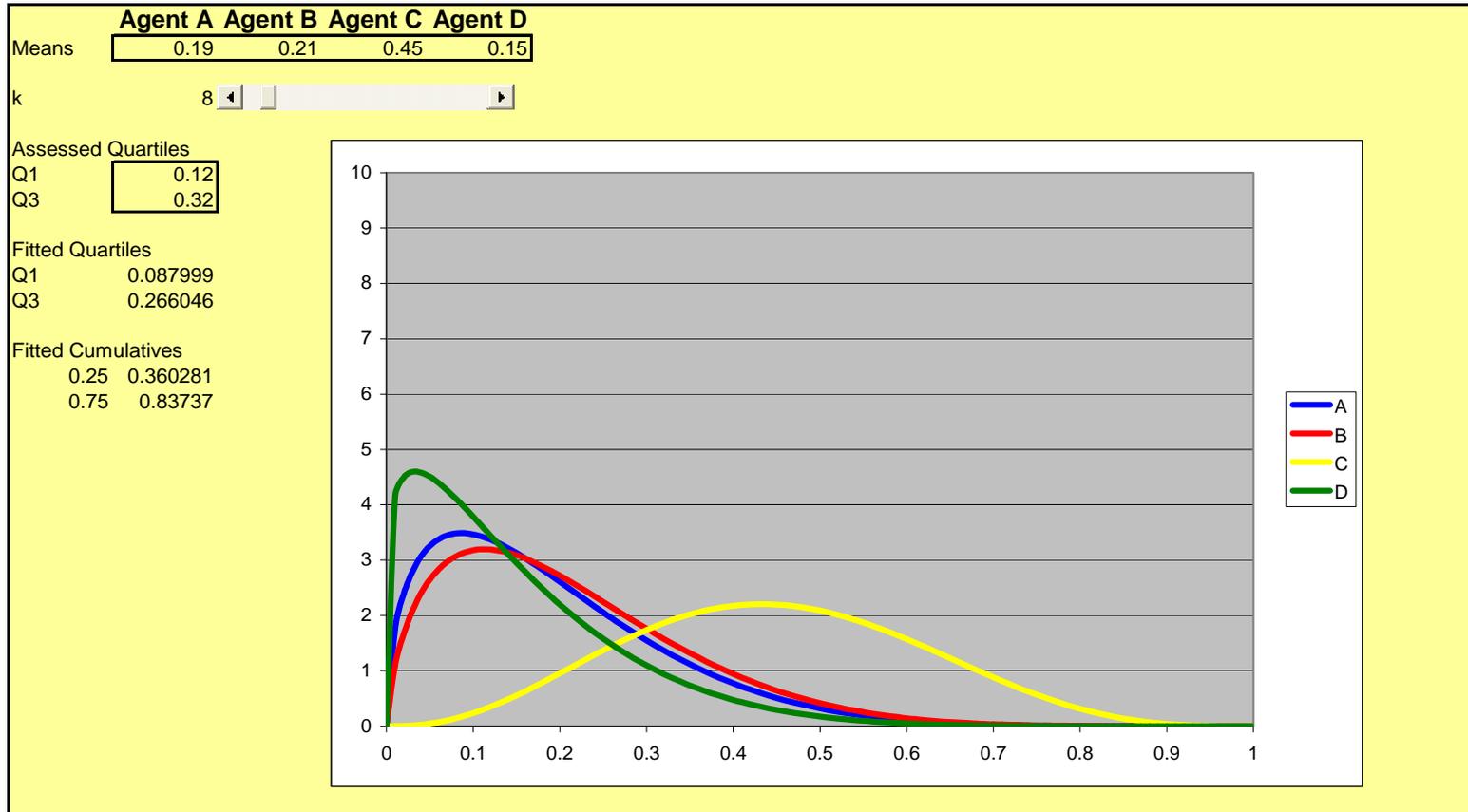
F(x)	x	Fitted x
0.05	0.02	0.03329
0.25	0.05	0.08035
0.5	0.12	0.1308
0.75	0.2	0.1959
0.95	0.3	0.31095

Mean 0.146

K 15.6



Probability Elicitation Tool: Joint Dirichlet



Expert Elicitation- Observations

- A few biological agents float to the top for all experts (and non-experts)
- Worked well with experts who had biological knowledge
- Some problems with experts who did not have biological knowledge
- Nevertheless: High correlation between experts' risk assessments (0.87)

Concluding Thoughts

- Expert probability elicitation is possible in the “front end” risk analysis of bioterrorism
 - Baseline the risks
 - Starting point for analyzing effects of defensive actions
- Need to be flexible in structuring the front end
 - Screen attack types and terrorist tactics
 - Hierarchical structuring seems promising
- Need to be flexible in the elicitation
 - Adjust to the expert’s way of thinking
 - Support with high-quality software