

# Risk Analysis for Homeland Security: Progress and Pitfalls

## Detlof von Winterfeldt

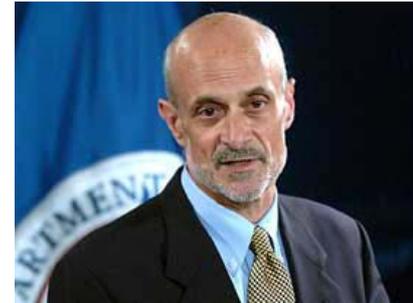
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**3<sup>rd</sup> Annual DHS University Network Summit**  
**Washington, DC March 17-19, 2009**

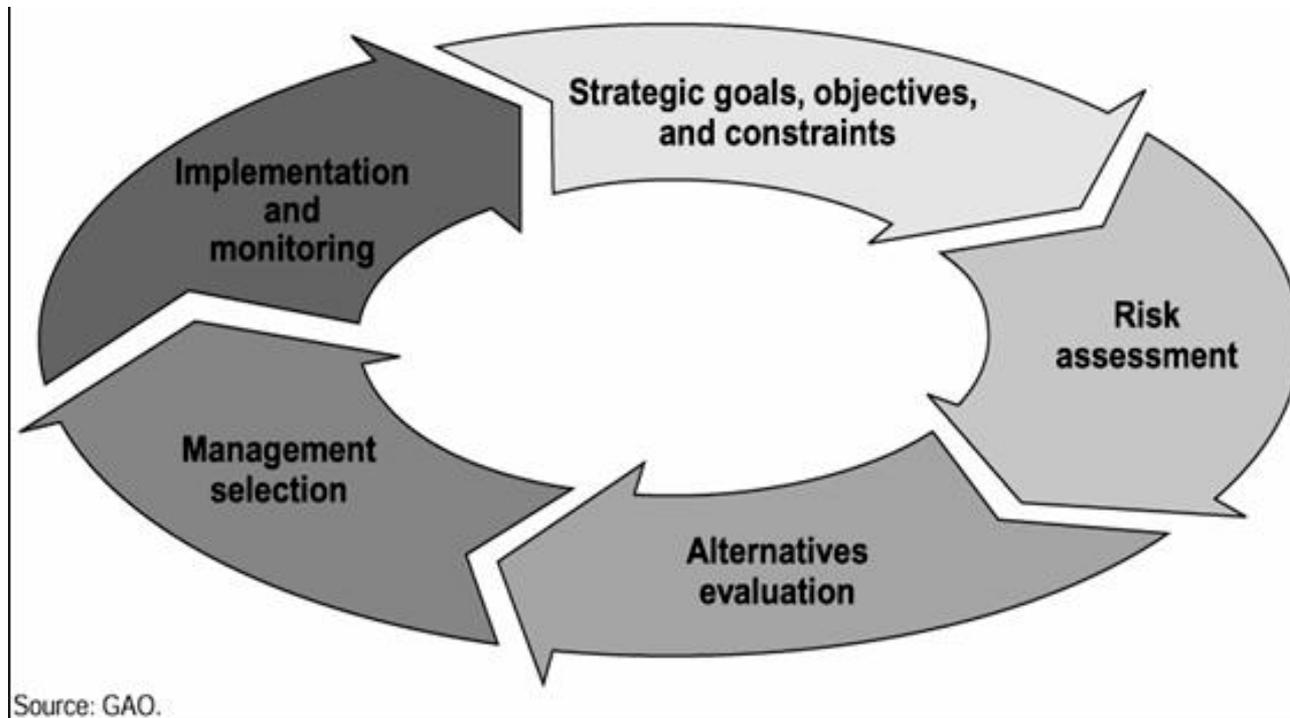


# Why Risk Analysis?

**“...We have to ... identify and prioritize risks -- understanding the threat, the vulnerability and the consequence. And then we have to apply our resources in a cost-effective manner..... “**



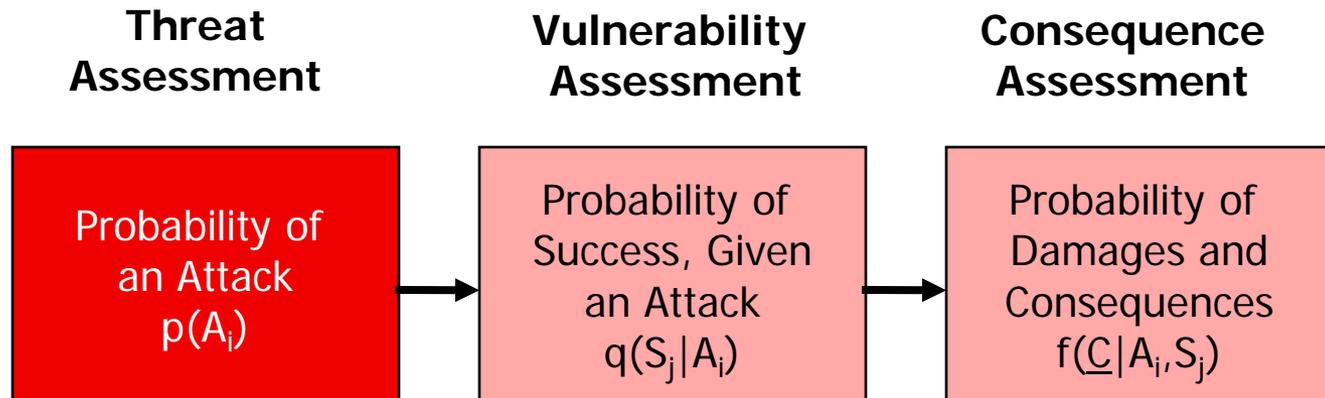
# GAO Risk Management Cycle



# GAO Risk Assessment Detail



# Terrorism Risk Analysis: Threat



# Lugar Report: Threat Probabilities

## Lugar Survey Probabilities of Major Attacks

| Event               | Median<br>Probability<br>(5 Years) | Median<br>Probability<br>(10 Years) | Appr.<br>Sample<br>Size |
|---------------------|------------------------------------|-------------------------------------|-------------------------|
| Nuclear Attack      | 10%                                | 20%                                 | 80                      |
| Biological Attack   | 10%                                | 20%                                 | 80                      |
| Chemical Attack     | 15%                                | 15%                                 | 80                      |
| Radiological Attack | 25%                                | 40%                                 | 80                      |

## Selected Participants in the Lugar Study

- Richard Allen
  - Graham Allison
  - Frank Carlucci
  - Bill Cohen
  - James Dobbins
  - Amitai Etziona
  - Bob Gallucci
  - Sig Hecker
  - Ron Lehman
  - Sam Nunn
  - Norman Schwarzkopf
  - Strobe Talbott
  - James Woolsey
- + 70 others

# We Can Do Better

- **Use the right experts**
  - Intelligence analysts
  - Social scientists studying terrorists behavior
  - Journalists
- **Ask the right questions**
  - Create a complete set of attack scenarios
  - Ask about motivations and capabilities
  - Ask for relative liklihoods
- **Use the right procedures**
  - Train experts and provide practice
  - Use state-of-the art elicitation protocols
  - Document carefully



# CREATE Participation in DHS Risk Assessments

- Bioterrorism Risk Assessment (BTRA)
- Risk Assessment Process for Informed Decision Making (RAPID)
- Risk and Intelligence Analysis Collaboration

# Bioterrorism Risk Assessment

- Bi-annual report to the President
- Prioritize biological threats
- Guide investments for risk management

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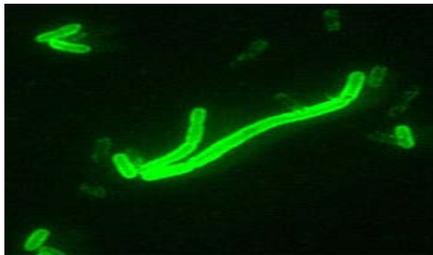
CREATE's role was to help with expert elicitation for threat assessment and with economic impact assessment

# Bioterrorism: Assessing the Risks



## **Bacillus Anthracis (Anthrax):**

- Non-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%

# Formal Expert Elicitation 1

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

## Formal Expert Elicitation 2

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

## Expert Elicitation- Observations

- A few biological agents float to the top for all experts – focus on those?
- Issues with sheer number of elicitations – boredom induced responses?
- Issues with expression of uncertainty – vague priors or deeper problems?
- Resistance by some intelligence analysts to express their judgments with numbers

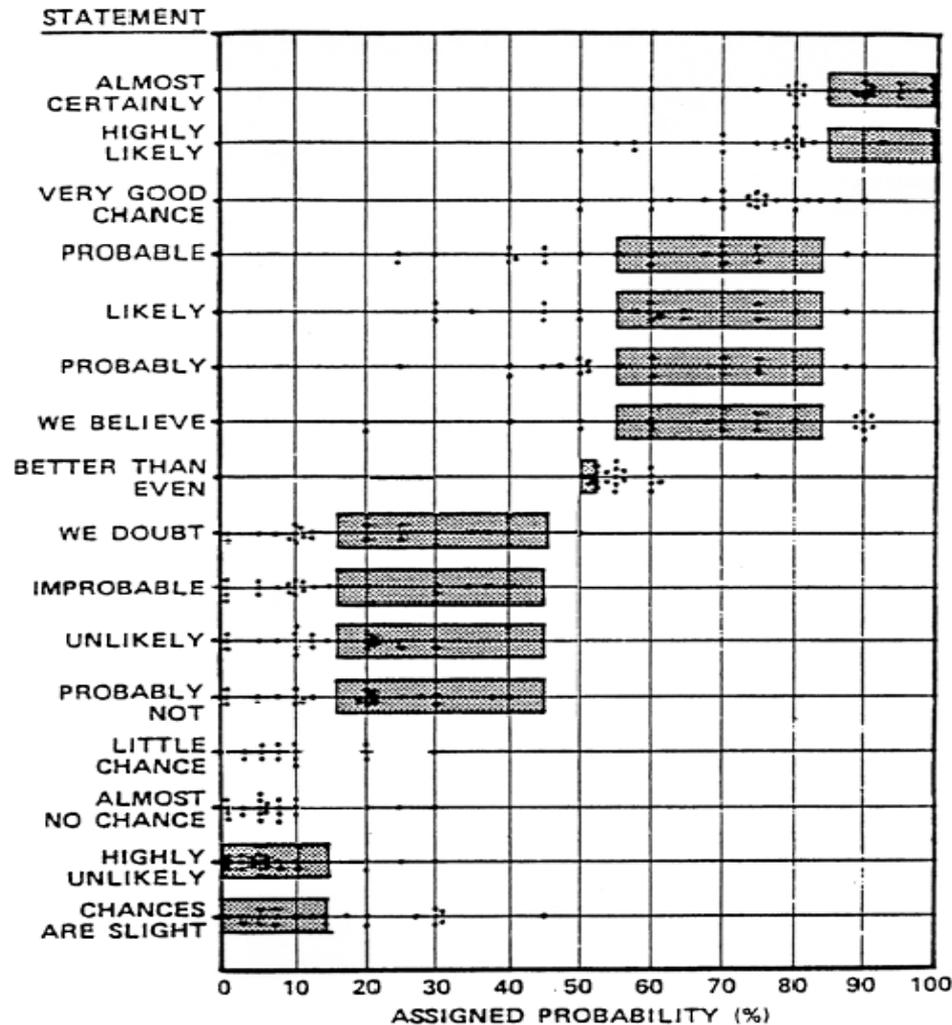


Figure 4.1. Relation between probabilities and verbal expressions. The shaded areas indicate Kent's (1964) proposal for matching words and probabilities. (Reprinted with permission of Decisions and Designs, Inc., from Barclay, Brown, Kelly, Peterson, Phillips, & Selvidge, 1977.)

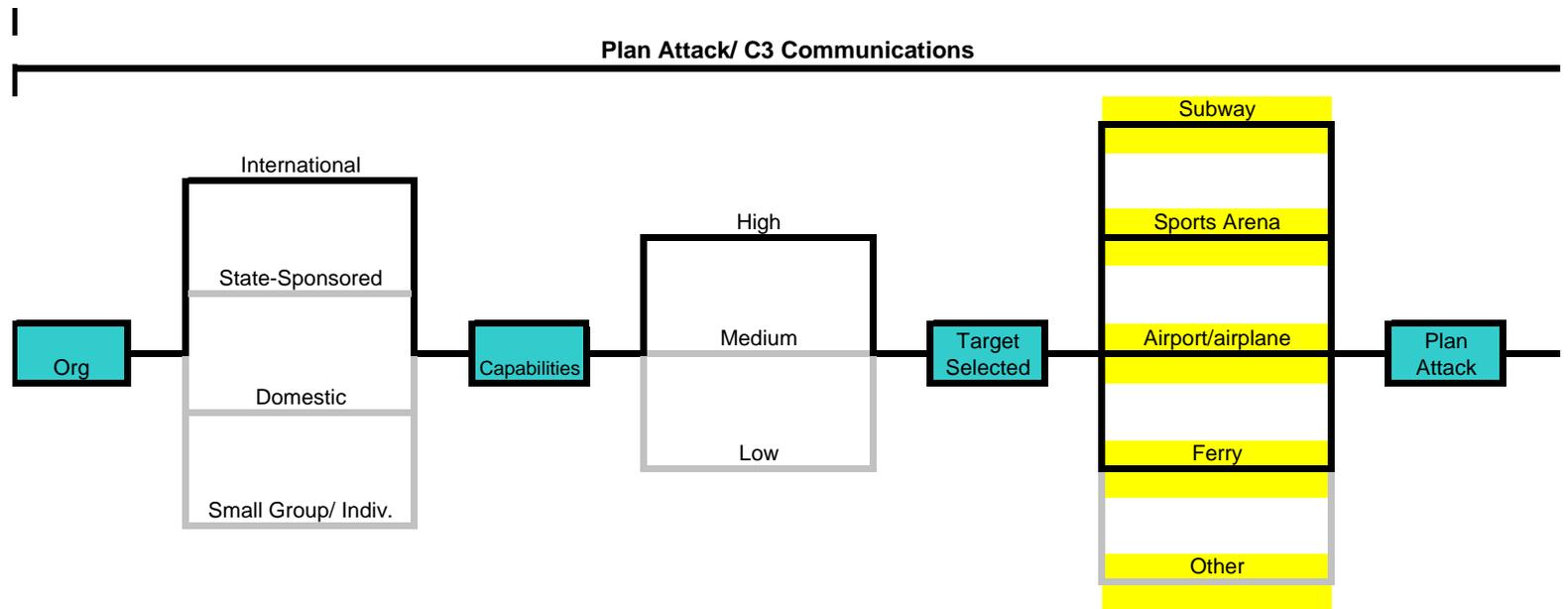
# RAPID: Overview

- Very ambitious effort to support DHS-wide planning and budgeting process
- Using 15 national planning scenarios
- Assessing threats with intelligence analysts using probability judgments
- Assessing vulnerabilities with red teams and attack trees
- Assessing consequences with models
- Assessing program effectiveness with program and budget managers

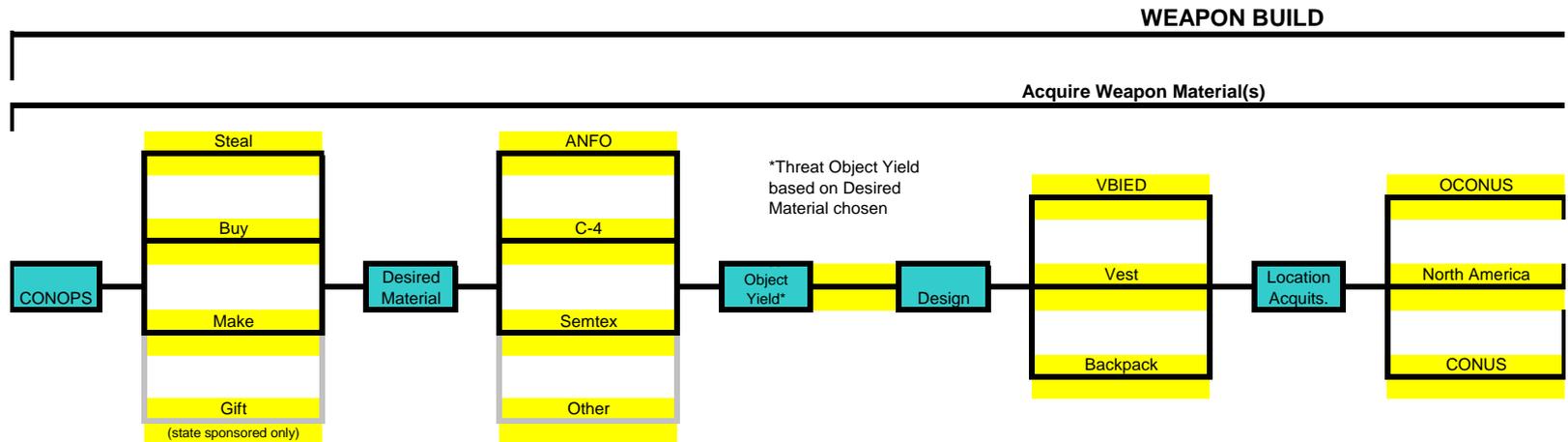
# RAPID: First spiral

- IED attack on public places
- Improvised nuclear device attack
- Attack on a chemical storage facility
- Anthrax attack on a city center
- Major hurricane

# Example – IED Attack Paths



# IED Attack Paths



# Probability Elicitation

## Dirichlet Elicitation Tool (DET)

This is the main menu of the DET.  
 Please input the date, project title, names of facilitator and expert in the greenly shaded areas.  
 In general, only use greenly shaded areas to provide inputs.  
 This main menu also provides navigation buttons to the other parts of the DET.

### STEP 1: Provide Information about Elicitation

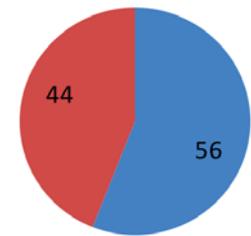
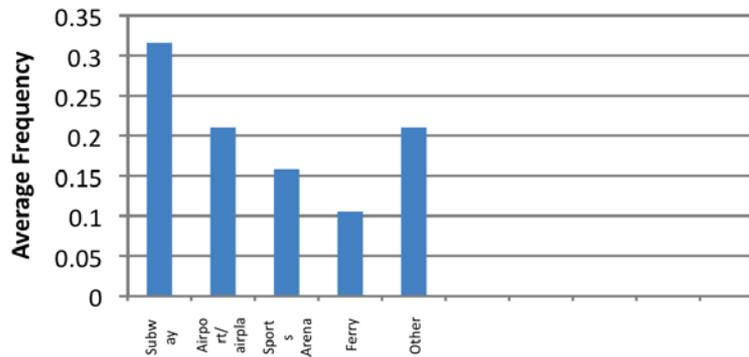
|              |                |  |  |
|--------------|----------------|--|--|
| Date:        | 7/27/08        |  |  |
| Project:     | RAPID - IED    |  |  |
| Facilitator: | Detlof         |  |  |
| Expert:      | Detlof         |  |  |
|              |                |  |  |
|              | Define Events  |  |  |
|              | Define k       |  |  |
|              | Summary Report |  |  |

## STEP 2: Define Events and Average Frequencies

Please define the events in the greenly shaded area and use any of the three modes to elicit their average frequencies (again using only the greenly shaded areas).  
**IMPORTANT:** make sure that you "Use" one of the calculated frequencies by clicking the appropriate button. You should then see the corresponding bar graph.

Return to Main Menu

| Event            | Avg. Freq.  |
|------------------|-------------|
| Subway           | 0.315789474 |
| Airport/airplane | 0.210526316 |
| Sports Arena     | 0.157894737 |
| Ferry            | 0.105263158 |
| Other            | 0.210526316 |



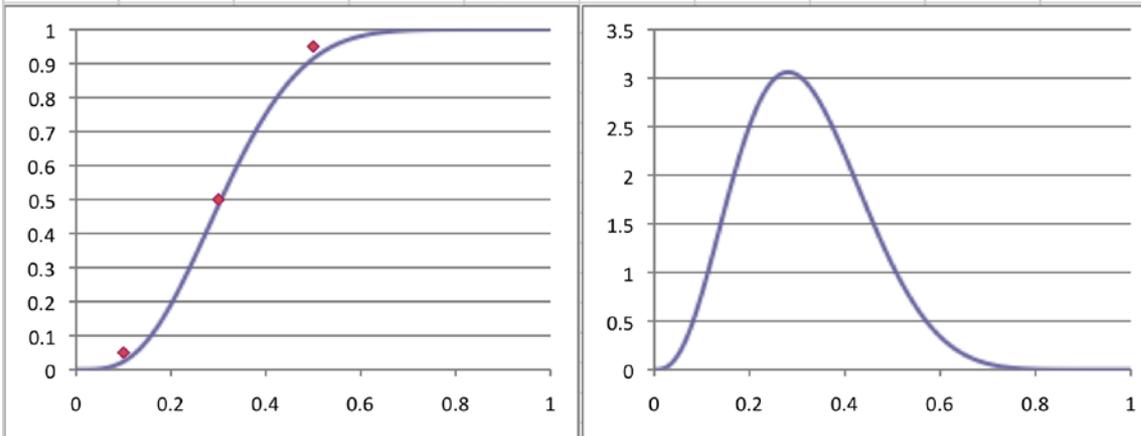
| Event            | Rank | Ratio | Avg. Freq. | Split Fraction | Avg. Freq. | Direct | Avg. Freq.  |
|------------------|------|-------|------------|----------------|------------|--------|-------------|
| Subway           | 1    |       |            |                | 1          | 0.3    | 0.315789474 |
| Airport/airplane | 2    |       |            |                |            | 0.2    | 0.210526316 |
| Sports Arena     | 3    |       |            |                |            | 0.15   | 0.157894737 |
| Ferry            | 4    |       |            |                |            | 0.1    | 0.105263158 |
| Other            | 5    |       |            |                |            | 0.2    | 0.210526316 |

### STEP 3: Define Scaling Parameter k

In this step, you can use the "slider" to adjust the scaling parameter k. Choose any event from the list box. You can then input fractiles in the greenly shaded areas and, by using the slider, visually fit the corresponding beta marginal. You also see the impact of the adjustments on all other marginal beta distributions.

Return to Main Menu

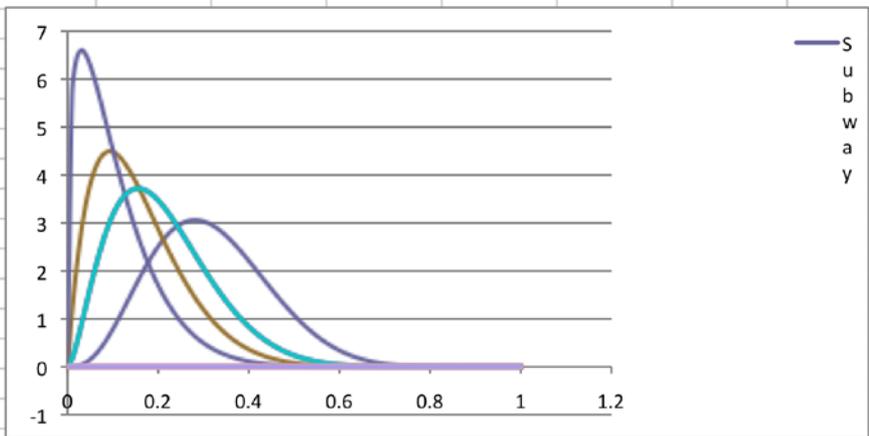
|        |             |          |   |          |
|--------|-------------|----------|---|----------|
| Subway | Event:      | Subway   | a | 3.966316 |
|        | Avg. Freq.: | 0.315789 | b | 8.593684 |



Change S scale



| F(x) | x   |
|------|-----|
| 0.05 | 0.1 |
| 0.5  | 0.3 |
| 0.95 | 0.5 |





## RAPID – Program Effectiveness Judgments

- Need to assess risk reduction due to DHS programs
- Many issues
  - What is baseline risk?
  - How to account for non-DHS programs?
  - Who should make the judgments?
  - How should the judgments be made?
  - How to account for deterrence
- Trial results were not encouraging

# Risk and Intelligence Analysts Collaboration

- Major workshop held in December 08
- Recognized need to bridge cultural differences
- Create a two-way collaboration
  - Work together on scenario construction
  - Simplify elicitation and ease the burden on intelligence analysts
  - Get high-level policy maker support to motivate intelligence analysts
- Help intelligence analysts with their job
  - Understand analysts' tasks
  - Build on models and tools currently used

## Final Observations

- Intelligence analysts can judge relative probabilities
  - Need to involve intelligence experts early
  - Keep it simple and allow flexibility
  - Allow expressions of uncertainty
- Level of analysis (scenarios) needs to be carefully chosen
  - Too detailed = too many judgments, too many interdependencies
  - Too aggregated = not clear what is being judged or on what basis

## Final Observations, continued

- Program effectiveness judgments are problematic
  - Can these judgments be made?
  - If yes, who should make them?
- Focus on risk management helps
  - Start with decision making framework
  - Many judgments won't matter
  - Design threat elicitation around those that matter
  - Make program effectiveness judgments very specific
  - Link program effectiveness to observable outcomes