Mod/Sim Technology Exchange
Sandia National Laboratories
Session 2, October 11, 2007

Uncertainty Analysis Tools
for Risk of Terrorist Acts

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What Led to Tool?

- **Need to Model Risk for Terrorist Acts to Rank Order Scenarios**
  - **Large Uncertainty**
    - **Significant Epistemic (State of Knowledge) Uncertainty**
  - **Many Variables are Linguistic, Not Numeric**
    - **Adversary Level of Technical Training**
    - **Religious Significance of Targets**

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What Problem is Tool Solving?

- **Rank Order Terrorist Scenarios by Risk**
  - Linguistic Variables → Fuzzy Sets, Approximate Reasoning
  - Epistemic Uncertainty → Belief/Plausibility Measure of Uncertainty
  - Rank Order Risk → Complementary Cumulative Belief/Plausibility Function

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Tools

- **LinguisticBelief**
  - **Custom Java Application**
  - **Linguistic Reasoning Model**
    - **Variables segregated into purely Linguistic Fuzzy Sets**
    - **Variables combined using Approximate Reasoning**
  - **Uncertainty measure: Belief/Plausibility**
    - **Superset of Probability to capture Epistemic uncertainty**
    - **Reduces to Probability for Specific Evidence**

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Tools

- **PoolEvidence**
  - **Custom Java Application**
  - **Pool Evidence from many Experts into Overall Evidence**
    - **Variables with purely Linguistic Fuzzy Sets**
    - **Evidence from Different Experts**

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Application to Terrorist Risk

- **Tools are Not Restricted to Evaluating Risk of Terrorist Acts**
  - **General Approximate Reasoning Model Framework**
- **Tools have Been Applied to Evaluating Risk of Terrorist Acts**

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Summary of Techniques and Tools

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Acknowledgments

- **Approximate Reasoning based on Logic Evolved Decision Techniques developed at LANL**
- **Assistance with Mathematics from Jon Helton, Arizona State/SNL**
- **Belief/Plausibility for Fuzzy Sets for Numeric Variables: Ron Yager paper**
- **Adversary Defender Model Concepts**
  - **Peter Merkle, SNL**
  - **Brian Bush, LANL**
- **Graphical Ranking Technique**
  - **John Cummings, SNL**

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References

- **"Evaluation of Risk from Acts of Terrorism: The Adversary/Defender Model using Belief and Fuzzy Sets", SAND2006-5777, September, 2006**

- **"Evaluation of Risk for Acts of Terrorism using Belief and Fuzzy Sets", <u>Journal of Nuclear Materials Management</u>, Winter, 2007, Volume XXXV, Number 2**

- **"LinguisticBelief: A Java Application for Linguistic Evaluation using Belief, Fuzzy Sets, and Approximate Reasoning", SAND2007-1299, March, 2007**

- **"Linguistic Evaluation of Terrorist Scenarios: Example Application", SAND2007-1301, March, 2007**

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Attributes of Framework

- **Adversary / Defender Viewpoints**
  - **Threat: Adversary Viewpoint**
  - **Vulnerability and Consequence: Defender Viewpoint**
- **Linguistic Evaluation with**
  - **Fuzzy Sets (words)**
  - **Not all variables are numeric**
    - **Combine Variables with Approximate Reasoning**
- **Capture and Propagate Uncertainty**
  - **Belief/Plausibility for epistemic uncertainty**
- **Clear Summary of Results for Decision Making**
  - **Simple but capture uncertainty**
- **Axiomatically Based**
  - **Use established mathematics**
- **Implemented in Java Software**

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Types of Uncertainty

- **Ambiguity**
  - **Uncertainty as to what will occur in the future**
    - **Dow Jones Industrial Average Close on Dec. 31, 2007**
      - **Will be one value**
      - **Ambiguity as to what that value will be**

- **Vagueness**
  - **Uncertainty as how to categorize a known outcome**
    - **Dow Jones close is 13,876 on Dec. 31, 2007**
      - **Is this "High" ?**
      - **What do you mean by "High"?**
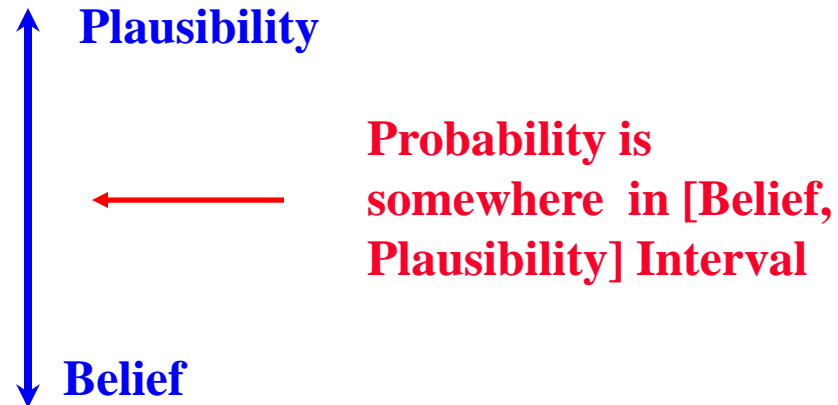 - **Vagueness can be expressed Linguistically (Words)**

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Ambiguity: Aleatory and Epistemic

- **For a Fair Coin**
  - **Uncertainty is Aleatory (random)**
  - **Probability Heads is ½**
  - **Probability Tails is ½**
- **But if we cannot toss coin, we do not know coin is fair, we do not even knows if coin has Heads and Tails**
  - **May not be Fair Coin (may be Weighted for Tails)**
  - **May be Two-Headed or Two-Tailed Coin**
  - **Epistemic (state of knowledge) uncertainty**
  - **Insufficient information to assign Probability to Heads and Tails**
  - **For Total Ignorance**
    - **Belief/Plausibility for Heads is 0/1**
    - **Belief/Plausibility for Tails is 0/1**
- **With more information (actually tossing the coin) we can reduce Epistemic Uncertainty**
  - **If at least one Heads and one Tails occur in a series of tosses, we know coin has Heads and Tails**
  - **Many tosses needed to assess if coin is fair**
- **For Fair Coin we cannot reduce aleatory uncertainty**

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Belief and Plausibility

- **Belief / Plausibility form a Lower / Upper Bound for Probability**
- **Belief is what probability will be**
- **Plausibility is what probability could be**

Plausibility

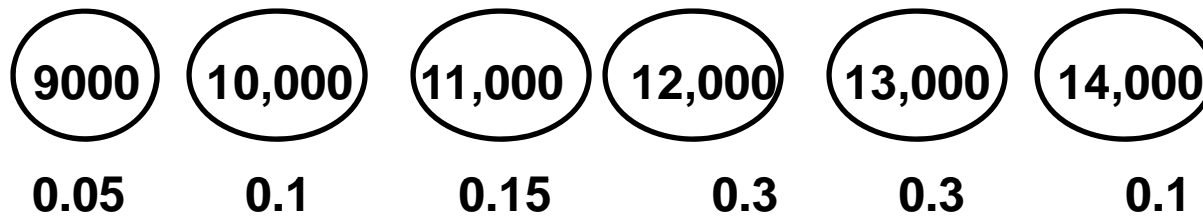**Probability is somewhere in [Belief, Plausibility] Interval**

Belief

- **Similar to a Confidence Interval for a Parameter of a probability distribution; a confidence measure that parameter is in interval, but exactly where in interval is not known**
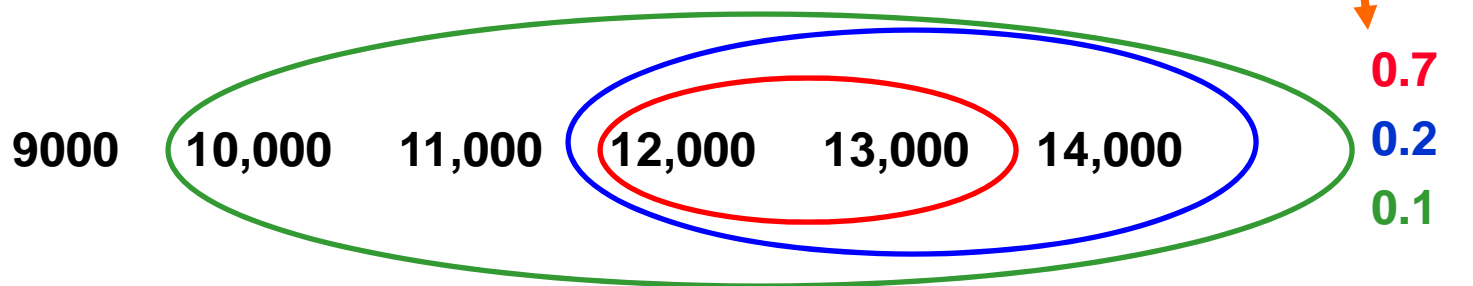- **Belief/Plausibility both reduce to Probability if Evidence is Specific**

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Example of Evidence:
Predict Stock Market Close Dec. 31, 2007

- **Probability**

(9000) (10,000) (11,000) (12,000) (13,000) (14,000)

0.05   0.1   0.15   0.3   0.3   0.1

Evidence

- **Belief/Plausibility**

9000   10,000   11,000   12,000   13,000   14,000

0.7
0.2
0.1

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Why is this useful?

- **What is Likelihood of Bio-Terror attack against a Major US City?**
  - **Frequency of Attack (per year) somewhere in [0, 1]**
  - **Point Estimate? Useless, too much uncertainty**
  - **Probability Distribution?**
    - **Must assign probability to each value in [0, 1]**
      - **Probability for 0 attacks per year is high**
      - **Probability assigned to 0 affects probabilities for all other values as must sum to 1.0**
        - **Is $P(0)$ = 0.01, 0.001, 0.00001, …? Don't Know**

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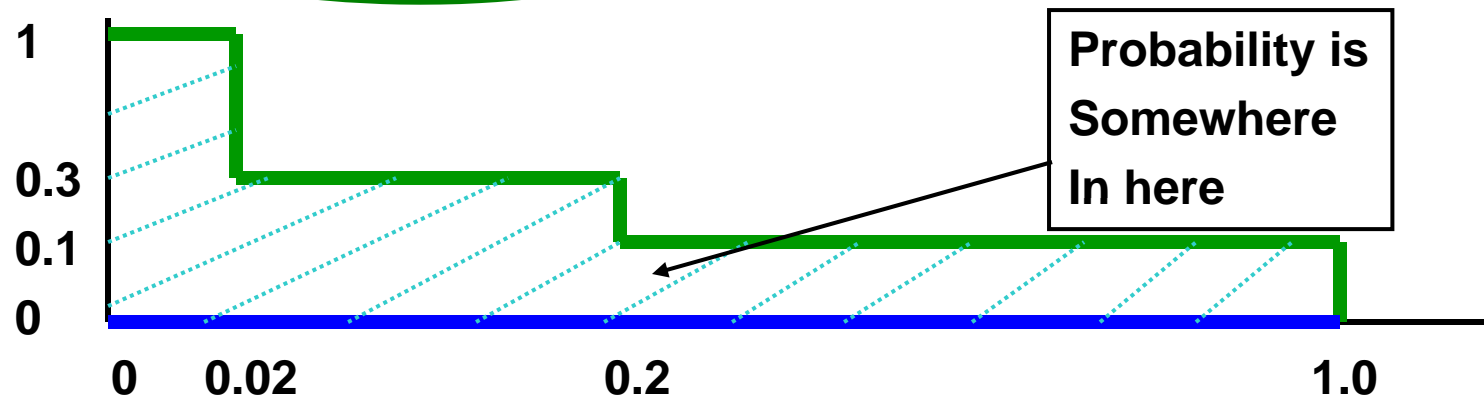
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Why is this useful?

- **Evidence is about 1 major Attack every 5 years (0.2/year)**
  - Assume Expert Opinion is: 10% Chance Attack is bio (0.02/year)

0   0.02   0.2   1.0

0.7
0.2
0.1

Likelihood Exceed Frequency:

Plausibility

Belief

1

0.3

0.1

0

Probability is Somewhere In here

0   0.02   0.2   1.0

Frequency (per year)

Automated in

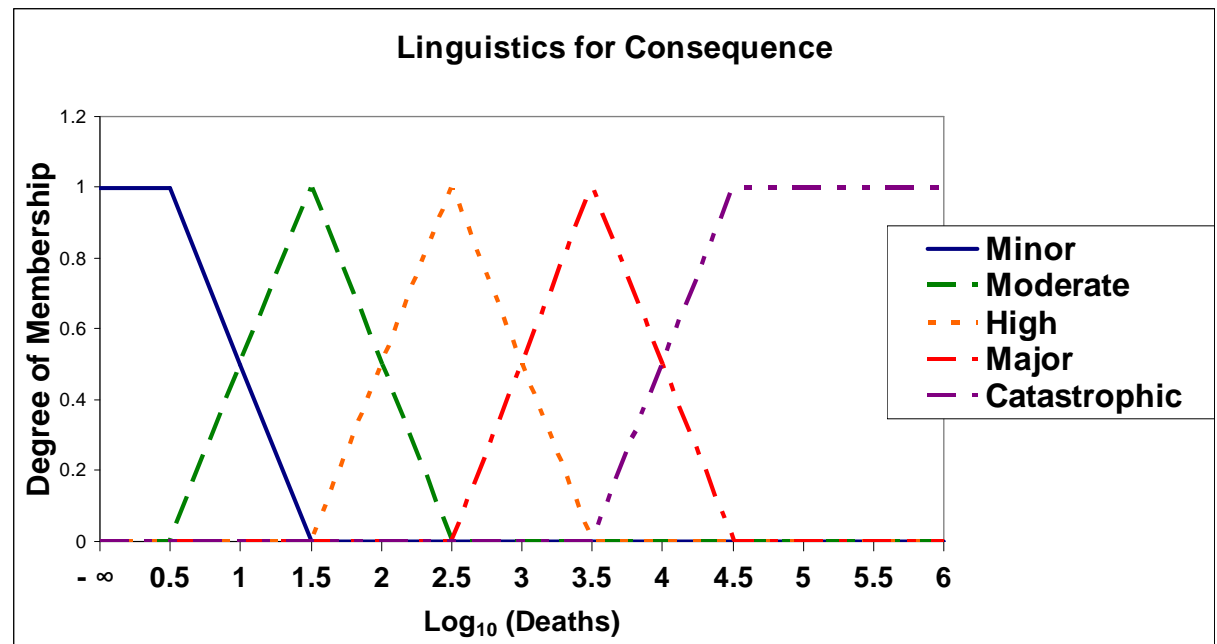*BeliefConvolution Java code*

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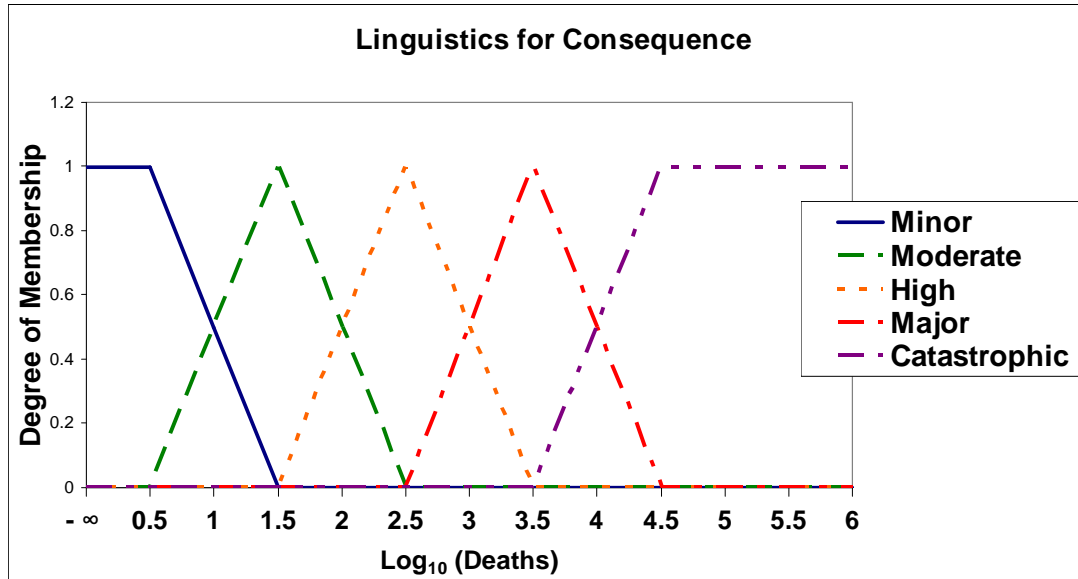National
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Vagueness
Fuzzy Sets for Numeric Variable

• **Represent Variable with Sets to reason at Fidelity Desired.** Above 30,000 deaths is "Catastrophic".

• **Use Fuzzy Sets to Avoid Sharp Distinction.** "Major" Deaths is Between *About* 1000 and *About* 10,000. 999 and 1001 deaths are each part "High" and part "Major".
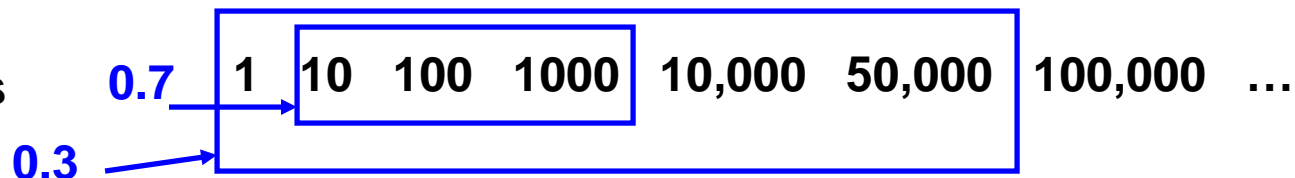
Linguistics for Consequence

Degree of Membership vs. Log_{10} (Deaths)

Legend:
- Minor
- Moderate
- High
- Major
- Catastrophic

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Uncertainty for Fuzzy Sets: Numeric Variable

Fuzzy Sets for Deaths

Linguistics for Consequence

Degree of Membership vs Log_{10} (Deaths)

- Minor
- Moderate
- High
- Major
- Catastrophic

Evidence For Deaths

0.7   1   10   100   1000   10,000   50,000   100,000   …

0.3

Uncertainty Distribution for Deaths:

	Minor	Moderate	High	Major	Catastrophic
Belief / Plausibility	0 / 0.65	0 / 1	0 / 1	0 / 0.65	0 / 0.3

18   (Calculated with BeliefConvolution code using Yager Method)

Why is this Important?

- **What is Likelihood of Bio-Terror attack against a Major US City?**
  - **Evidence is about 1 major Attack every 5 years (0.2/year)**
    - **Assume Expert Opinion is: 10% Chance Attack is bio (0.02/year)**
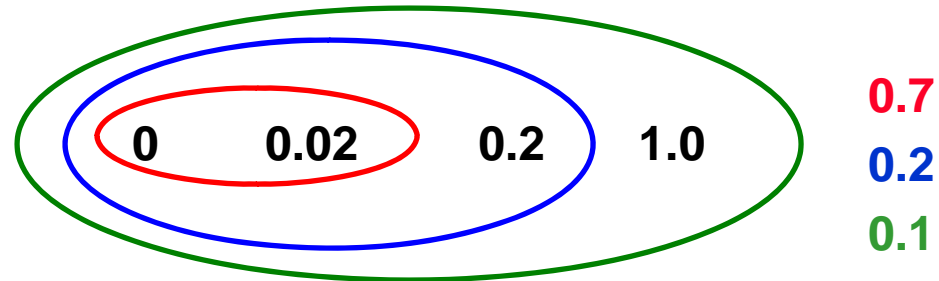- **Assume Following Fuzzy Sets for Evaluating Frequency of Attack**
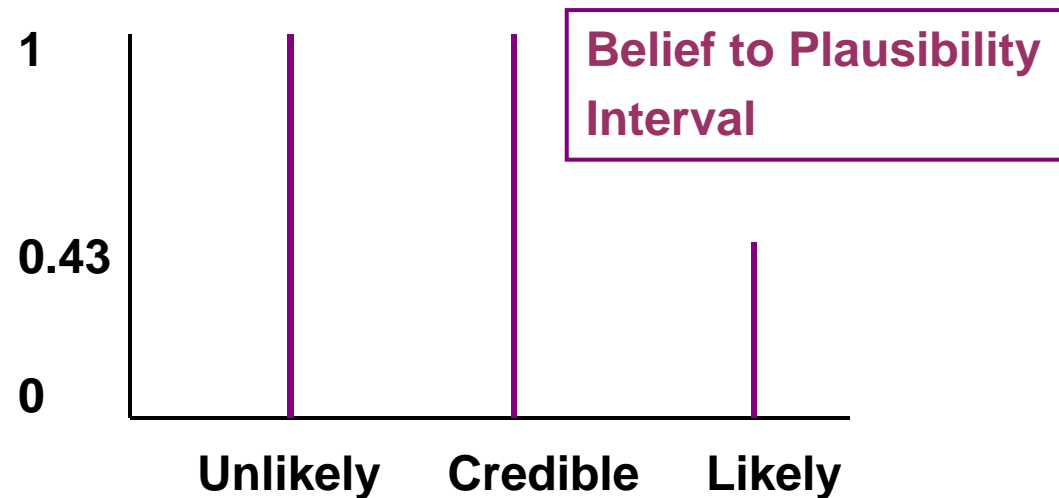
Defender Fuzzy Sets for Threat

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Why is this Important?

Evidence

0   0.02   0.2   1.0

0.7
0.2
0.1

Likelihood
For Frequency

1

0.43

0

Belief to Plausibility Interval

Unlikely   Credible   Likely

(Calculated with BeliefConvolution code using Yager Method)

Frequency of Attack (per year)

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Fuzzy Sets for Non-Numeric Variable

Adversary Level of Technical Training:

High School

Bachelors

Advanced

Do NOT Force Numeric Measure: Requires Arbitrary Scale

Adversary Level of Technical Training:

High School = 1?

Bachelors = 2?

Advanced = 3?

Adversary Level of Technical Training:

High School = 10?

Bachelors = 100?

Advanced = 1000?

Use Approximate Reasoning:

Mathematics for combining words

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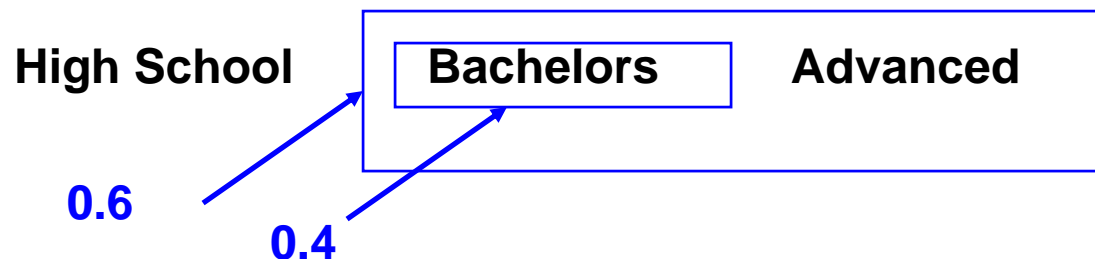
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Uncertainty for Fuzzy Sets: Non-Numeric Variable

- **Fuzzy Sets for Adversary Level of Technical Training**
  - High School   Bachelors   Advanced
- **Evidence**

  High School   Bachelors   Advanced

  0.6

  0.4

- **Uncertainty Distribution: Belief / Plausibility**

High School	Bachelors	Advanced
0/ 0	0.4 / 1	0 / 0.6

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Approximate Reasoning

- **Mathematics for Combining Words**
- **If we use Words instead of numbers we need a way of combining the Words for Different Variables**
- **Implemented as A Rule Base for Combining Fuzzy Sets from Different Variables**

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Approximate Reasoning

Approximate Reasoning is a Rule Base for Combining Fuzzy Sets

Rules for selected RuleLinguistic

Rules for RuleLinguistic: expected consequence

Fuzzy Set for Input Linguistic: consequence	Fuzzy Set for Input Linguistic: probabilityOfSuccess	Output Fuzzy Set for Rule (blank if rule not set)
small	low	No
small	medium	No
small	high	No
medium	low	No
medium	medium	No
medium	high	Maybe
large	low	No
large	medium	Maybe
large	high	Yes

Specify Output Fuzzy Set for Selected Rule | No ▼

Accept Rules as Shown   **Cancel**

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Approach

- **Evaluate Risk of Scenarios for Specific Adversary Groups**
  - **Risk a function of: Threat, Vulnerability, Consequence**
    - **Risk = Threat x Vulnerability x Consequence, or**
    - **Risk = Likelihood that (Threat x Vulnerability) Exceeds Consequence**
  - **Different Adversary Groups have Different Resources and Different Goals**

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Approach

- **Scenario is: Target, Adversary Resources, Attack Plan, and Consequence for a Specific Adversary Group**
  - **Resources consist of**
    - **Attributes (Numbers, Equipment, Weapons, Technical Expertise, etc.)**
    - **Information (Insider, Reconnaissance, etc.)**
  - **Scenario is Defined to the Level Needed for Evaluation**
    - **A scenario for Pantex**
    - **A scenario against any of 1000 similar targets**
- **Rank Order Scenarios by Risk**
  - **No attempt to mathematically combine "all" scenarios**
    - **Infinite number of scenarios**

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Adversary / Defender

- **Each has Different Knowledge and Goals**
- **Adversary**
  - **IS the Threat**
    - **No uncertainty in Scenarios**
  - **Has More Uncertainty than Defender for Vulnerability and Consequence**
  - **Some Desired Consequences Different from Defender**
    - **Deaths (of concern to defender)**
    - **Religious significance (of little concern to defender)**
- **Defender**
  - **Large Epistemic Uncertainty for Threat Scenarios**
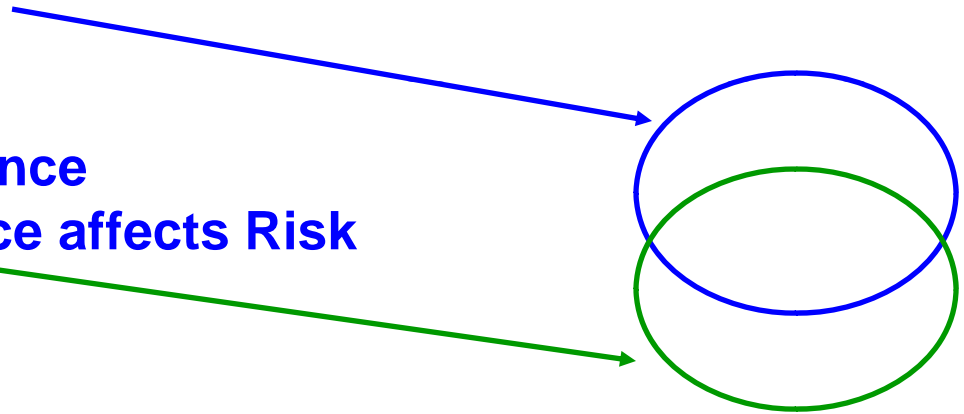 - **Less Uncertainty than Adversary for Vulnerability and for Consequence of concern to defender**

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Risk for a Scenario

- **Risk a function of**
  - **Threat = Likelihood of Adversary Attack**
    - **Estimated by Defender "thinking like the adversary"**
      - **Adversary Estimate of Expected Consequence**
      - **Many Different Consequences for Adversary**
  - **Vulnerability = Likelihood of Adversary Success**
    - **Estimated by the Defender given the Attack is Attempted**
  - **Consequence**
    - **Estimated by the Defender given the Attack is Successful**
    - **Many Different Consequences for Defender**

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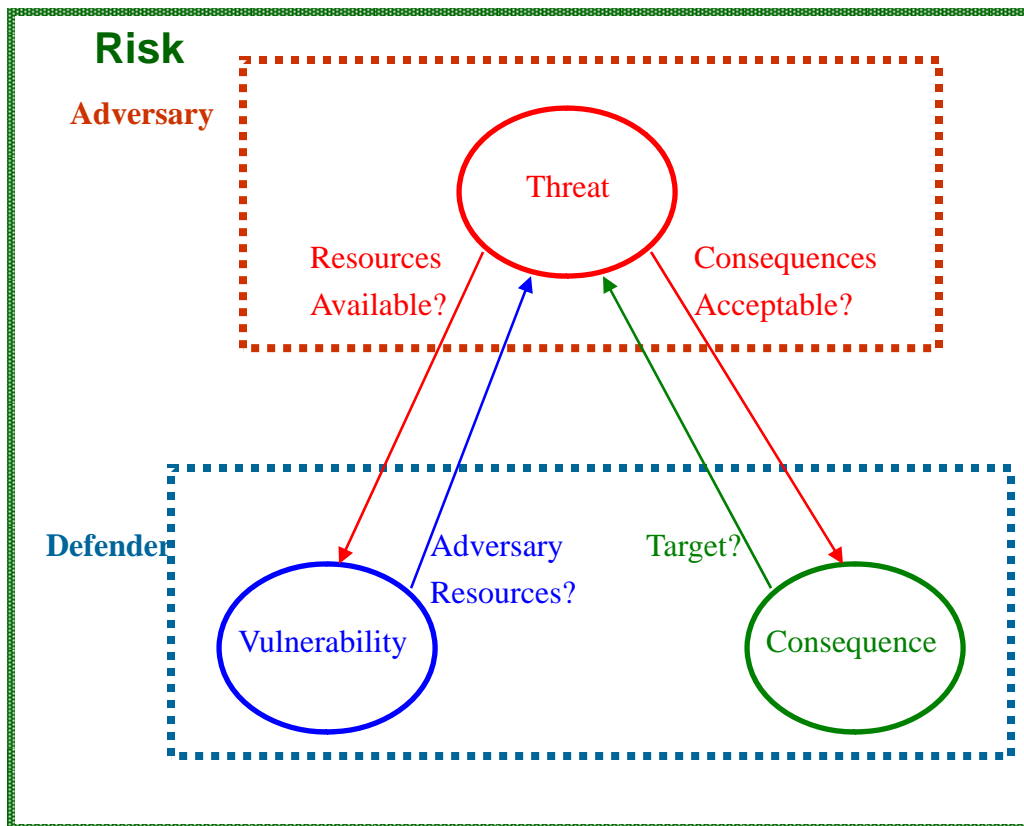# Adversary and Defender Consequence

- **Not necessarily the same**
- **Adversary Consequence affects Threat**
  - **Deaths**
  - **Economic Damage**
  - **Religious Significance**
- **Defender Consequence affects Risk**
  - **Deaths**
  - **Economic Damage**
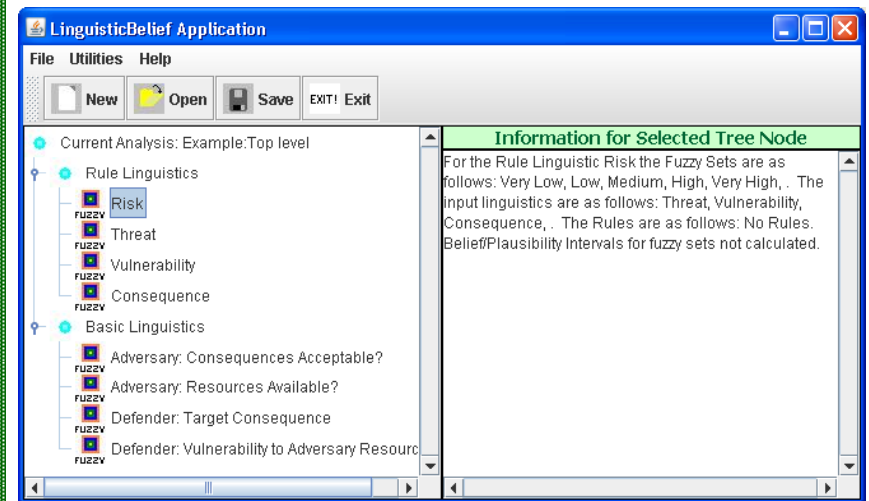 - **Regional Effects**

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Adversary/Defender Model

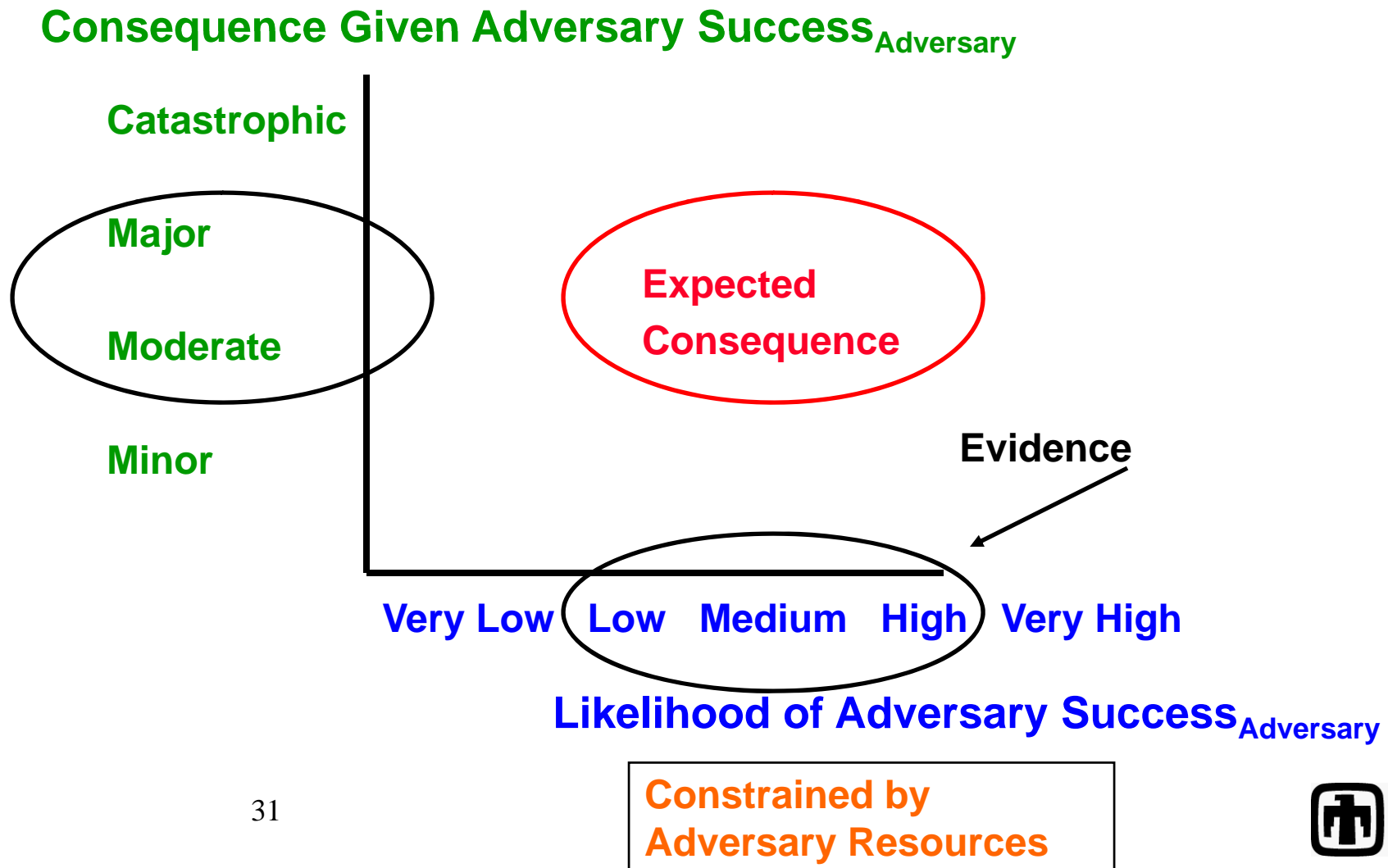**The Concept:**

Adversary Defender

Interaction Model

The Software: LinguisticBelef

Linguistic Reasoning with Uncertainty

- •**Fuzzy Sets**
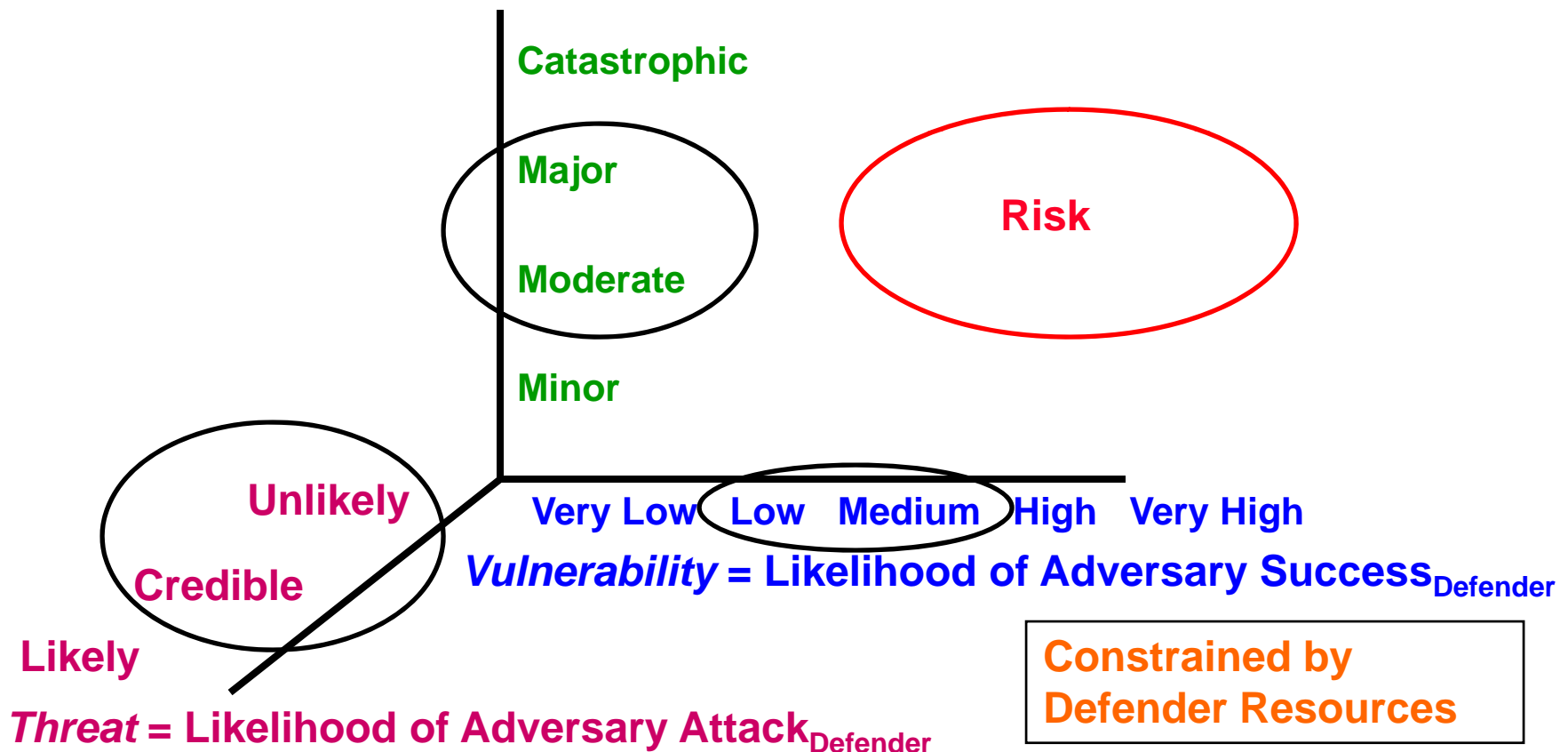- •**Approximate Reasoning**
- •**Belief/Plausibility**

Risk

Adversary

Threat

Resources
Available?

Consequences
Acceptable?

Defender

Adversary
Resources?

Target?

Vulnerability

Consequence

LinguisticBelief Application

File   Utilities   Help

New   Open   Save   EXIT! Exit

Current Analysis: Example:Top level

Rule Linguistics

FUZZY Risk

FUZZY Threat

FUZZY Vulnerability

FUZZY Consequence

Basic Linguistics

FUZZY Adversary: Consequences Acceptable?

FUZZY Adversary: Resources Available?

FUZZY Defender: Target Consequence

FUZZY Defender: Vulnerability to Adversary Resourc

Information for Selected Tree Node

For the Rule Linguistic Risk the Fuzzy Sets are as
follows: Very Low, Low, Medium, High, Very High, . The
input linguistics are as follows: Threat, Vulnerability,
Consequence, . The Rules are as follows: No Rules.
Belief/Plausibility Intervals for fuzzy sets not calculated.

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Adversary Model

Consequence Given Adversary Success$_{Adversary}$

Catastrophic

Major

Moderate

Expected Consequence

Minor

Evidence

Very Low   Low   Medium   High   Very High

Likelihood of Adversary Success$_{Adversary}$

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Constrained by Adversary Resources

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Defender Model

Consequence = Consequence given Adversary Success$_{Defender}$

Catastrophic

Major

Risk

Moderate

Minor

Unlikely   Very Low   Low   Medium   High   Very High

Credible   **Vulnerability** = Likelihood of Adversary Success$_{Defender}$

Likely

Threat = Likelihood of Adversary Attack$_{Defender}$

Constrained by Defender Resources

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From the Adversary Model

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Evaluation

- **Top Level Variables are Combination of Lower Level Variables using approximate reasoning (x is convolution per rule base, not multiplication)**

  - $\text{Consequence}_{\text{Adversary}}$ = Deaths x Economic Damage x Religious Significance

  - $\text{Consequence}_{\text{Defender}}$ = Deaths x Economic Damage x Regional Effects

  - $\text{Likelihood of Success}_{\text{Adversary}}$ = Ability to Gather Information x Availability of Technical Expertise x Likelihood not Detected gathering Attributes x Likelihood Defeat Security System

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Each Variable Segregated Into Fuzzy Sets

Some Variables are Numeric: "Deaths"

Linguistics for Consequence

Fuzzy Sets for Consequence (Deaths)

Some Variables are Not Numeric: "Technical Expertise"

Adversary Level of Technical Training:

High School

Bachelors

Advanced

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Variables Combined with Approximate Reasoning

Rules for selected RuleLinguistic

Rules for RuleLinguistic: Risk

Fuzzy Set for Input Linguistic: Threat	Fuzzy Set for Input Linguistic: Vulnerability	Fuzzy Set for Input Linguistic: Consequence	Output Fuzzy Set for Rule (blank if rule not set)
unlikely	Very Low	very low	Negligible
unlikely	Very Low	low	Negligible
unlikely	Very Low	medium	Negligible
unlikely	Very Low	high	Negligible
unlikely	Very Low	very high	Negligible
unlikely	Low	very low	Negligible
unlikely	Low	low	Negligible
unlikely	Low	medium	Negligible
unlikely	Low	high	Negligible
unlikely	Low	very high	Negligible
unlikely	Medium	very low	Negligible
unlikely	Medium	low	Negligible
unlikely	Medium	medium	Negligible
unlikely	Medium	high	Negligible
unlikely	Medium	very high	Negligible
unlikely	High	very low	Negligible
unlikely	High	low	Negligible
unlikely	High	medium	Negligible
unlikely	High	high	Low
unlikely	High	very high	Medium
credible	Very Low	very low	Negligible
credible	Very Low	low	Negligible
credible	Very Low	medium	Negligible
credible	Very Low	high	Negligible
credible	Very Low	very high	Low
credible	Low	very low	Low
credible	Low	low	Low

Specify Output Fuzzy Set for Selected Rule   Choices Are: ▼

Accept Rules as Shown   Cancel

Example Model in LinguisticBelief Code

LinguisticBelief Application

File   Utilities   Help

New   Open   Save   EXIT! Exit

Current Analysis: National Planning Scenario

Rule Linguistics
- Long Term Consequence
- Casualties (Equivalent Dead)
- Adversary Estimate Consequence
- Adversary Estimate Information Required
- Detect Adversary Gathering Information
- Adversary Estimate Scientific/Engineering Attributes Required
- Detect Adversary Gathering Scientific/Engineering Attributes
- Adversary Estimate Attributes Required
- Adversary Estimate Resources Required
- Detect Adversary Gathering Attributes
- Immediate Consequence
- Detect Adversary Gathering Resources
- Vulnerability
- Consequence
- Adversary Estimate Vulnerability
- Threat
- Risk

Basic Linguistics
- Dead
- Injured/Ill
- Infrastructure Damage
- Evacuation
- Contamination
- National Economic Impact

Information for Selected Tree Node

fuzzy sets: credible, Very Low, medium, -- Rule output fuzzy set: Negligible*, * Rule input fuzzy sets: credible, Very Low, high, -- Rule output fuzzy set: Negligible*, * Rule input fuzzy sets: credible, Very Low, very high, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Low, very low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Low, low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Low, medium, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Low, high, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Low, very high, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Medium, very low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Medium, low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Medium, medium, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, Medium, high, -- Rule output fuzzy set: Medium*, * Rule input fuzzy sets: credible, Medium, very high, -- Rule output fuzzy set: High*, * Rule input fuzzy sets: credible, High, very low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, High, low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: credible, High, medium, -- Rule output fuzzy set: Medium*, * Rule input fuzzy sets: credible, High, high, -- Rule output fuzzy set: High*, * Rule input fuzzy sets: credible, High, very high, -- Rule output fuzzy set: Extreme*, * Rule input fuzzy sets: likely, Very Low, very low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Very Low, low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Very Low, medium, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Very Low, high, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Very Low, very high, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Low, very low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Low, low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Low, medium, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Low, high, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Low, very high, -- Rule output fuzzy set: Medium*, * Rule input fuzzy sets: likely, Medium, very low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, Medium, low, -- Rule output fuzzy set: Medium*, * Rule input fuzzy sets: likely, Medium, medium, -- Rule output fuzzy set: High*, * Rule input fuzzy sets: likely, Medium, high, -- Rule output fuzzy set: High*, * Rule input fuzzy sets: likely, Medium, very high, -- Rule output fuzzy set: High*, * Rule input fuzzy sets: likely, High, very low, -- Rule output fuzzy set: Low*, * Rule input fuzzy sets: likely, High, low, -- Rule output fuzzy set: Medium*, * Rule input fuzzy sets: likely, High, medium, -- Rule output fuzzy set: High*, * Rule input fuzzy sets: likely, High, high, -- Rule output fuzzy set: Extreme*, * Rule input fuzzy sets: likely, High, very high, -- Rule output fuzzy set: Extreme*, . [Belief, Plausibility] Intervals for fuzzy sets are as follows : Fuzzy Set: Negligible [0.000, 0.384], Fuzzy Set: Low [0.000, 0.349], Fuzzy Set: Medium [0.155, 1.000], Fuzzy Set: High [0.000, 0.720], Fuzzy Set: Extreme [0.000, 0.000], .
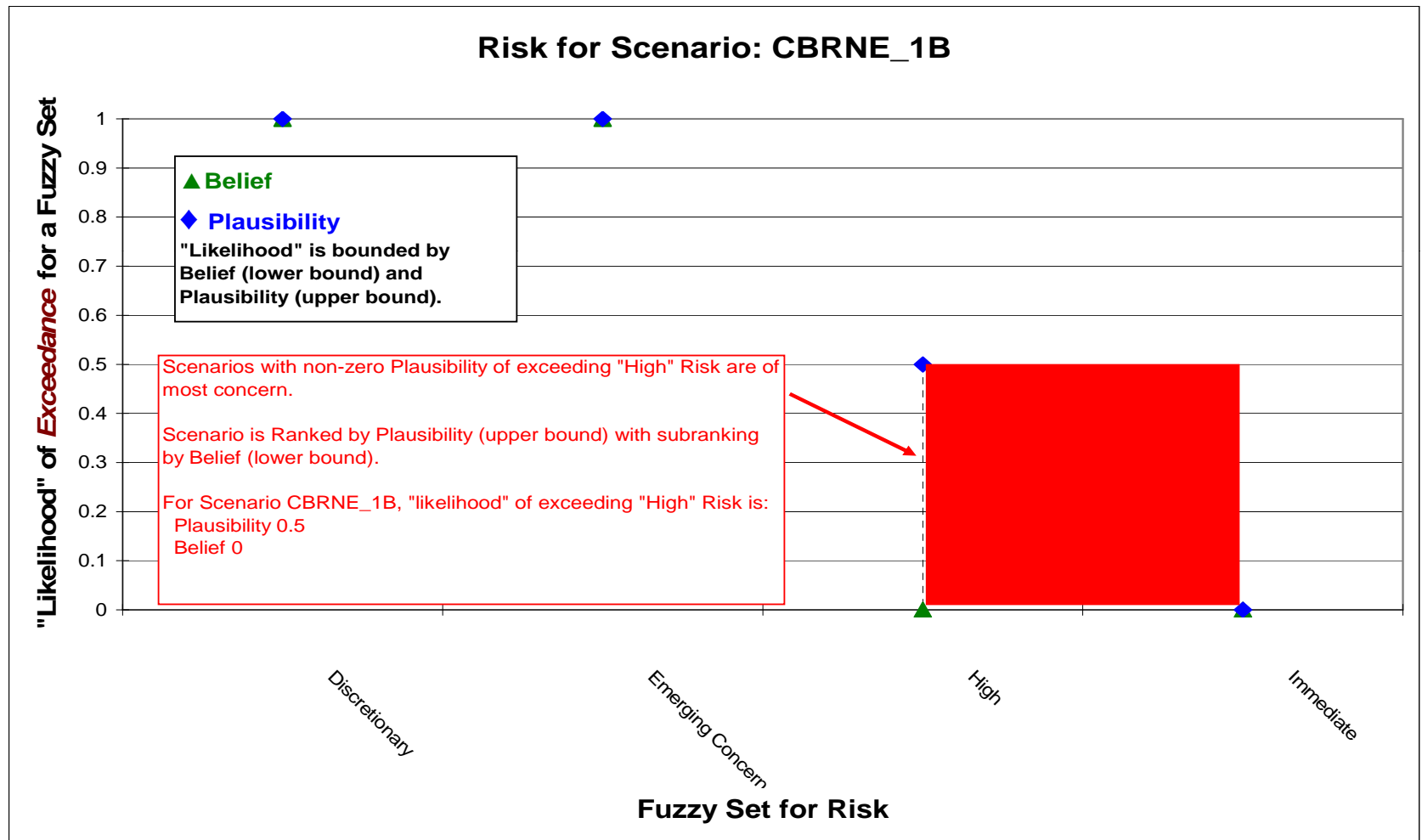
Rank Order Scenarios by Risk

- **Rank a scenario by the Highest Non-Zero Plausibility of Exceeding the "Worst" Fuzzy Set**
  - For Scenarios with Equal Plausibility, Subrank by Highest Belief
  - Extension of "Probability of Exceedance" approach
    - Uses Fuzzy Sets instead of Numbers
    - Uses Belief/Plausibility Interval instead of Probability
  - Can be "Color Coded"
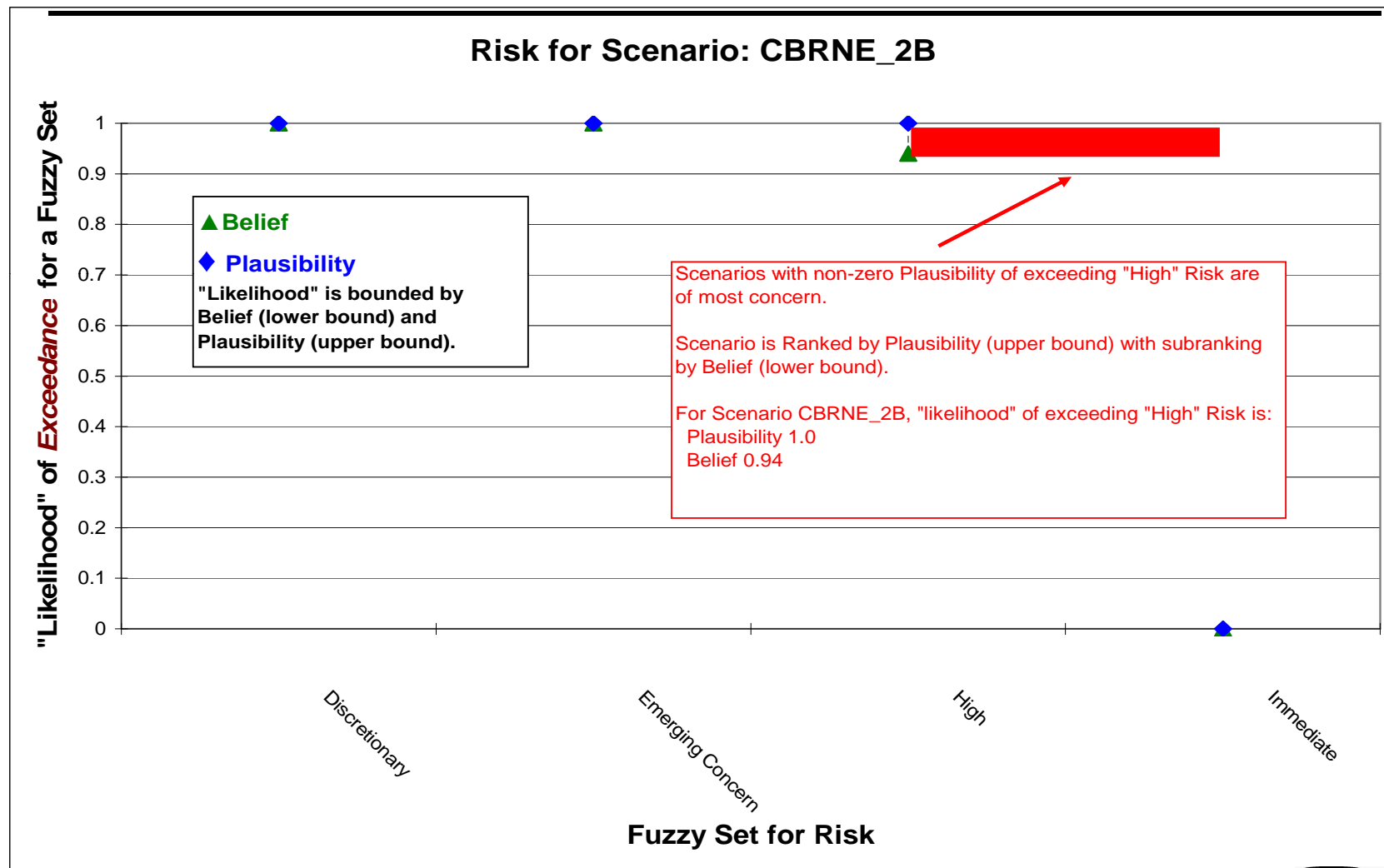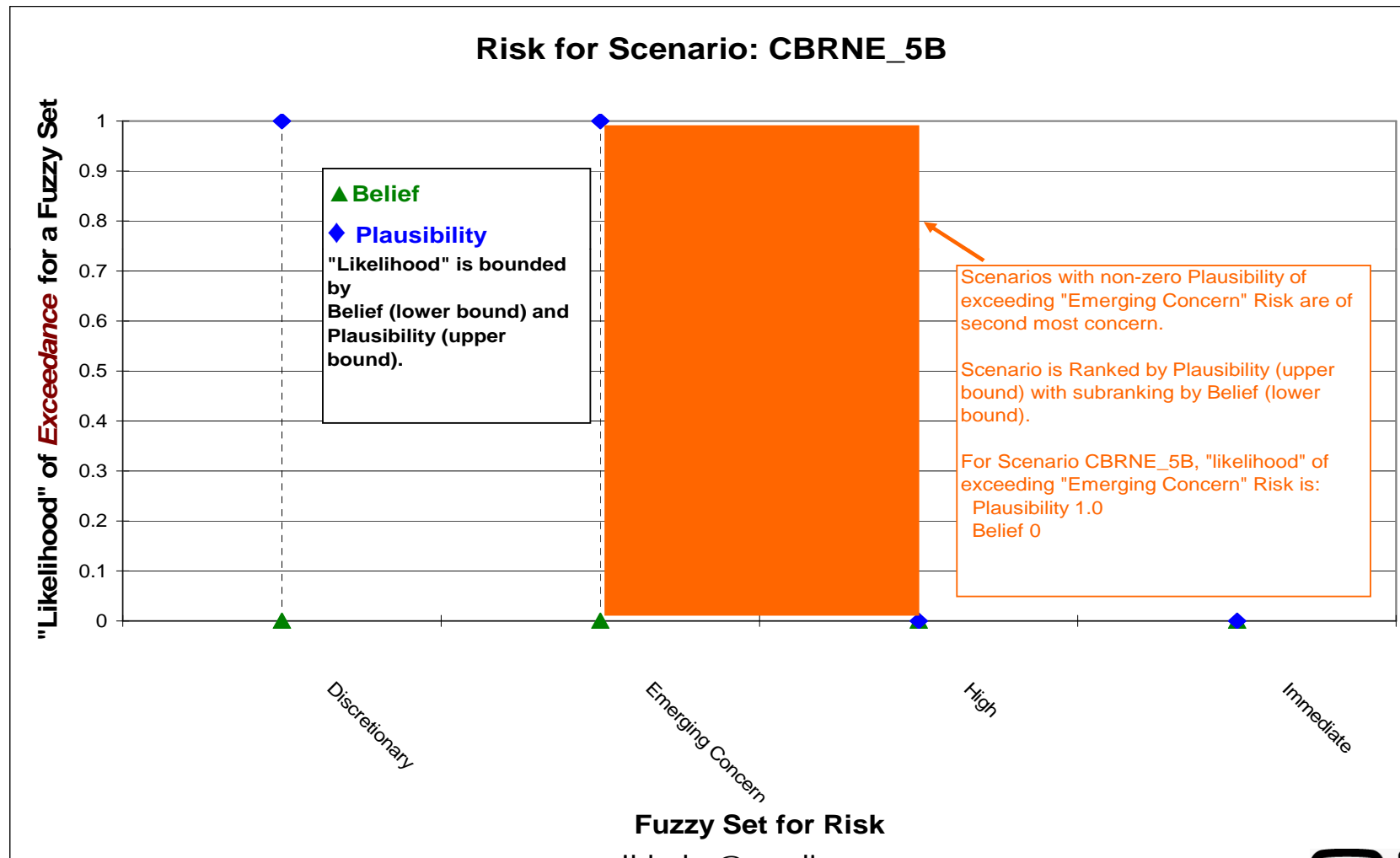   - Shown for 3 of 5 scenarios in Following from SAND2007-1301

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Rank Order Results

Risk for Scenario: CBRNE_1B

▲ **Belief**

◆ **Plausibility**

"Likelihood" is bounded by Belief (lower bound) and Plausibility (upper bound).

Scenarios with non-zero Plausibility of exceeding "High" Risk are of most concern.

Scenario is Ranked by Plausibility (upper bound) with subranking by Belief (lower bound).

For Scenario CBRNE_1B, "likelihood" of exceeding "High" Risk is:
  Plausibility 0.5
  Belief 0

Y-axis: **"Likelihood" of *Exceedance* for a Fuzzy Set**

X-axis labels: Discretionary, Emerging Concern, High, Immediate

Fuzzy Set for Risk

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Rank Order Results

Risk for Scenario: CBRNE_2B

▲ Belief

♦ Plausibility

"Likelihood" is bounded by Belief (lower bound) and Plausibility (upper bound).

Scenarios with non-zero Plausibility of exceeding "High" Risk are of most concern.

Scenario is Ranked by Plausibility (upper bound) with subranking by Belief (lower bound).

For Scenario CBRNE_2B, "likelihood" of exceeding "High" Risk is:
 Plausibility 1.0
 Belief 0.94

"Likelihood" of *Exceedance* for a Fuzzy Set

Fuzzy Set for Risk

Discretionary   Emerging Concern   High   Immediate

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Rank Order Results

Risk for Scenario: CBRNE_5B

Legend:
- ▲ Belief
- ◆ Plausibility

"Likelihood" is bounded by
Belief (lower bound) and
Plausibility (upper bound).

Scenarios with non-zero Plausibility of exceeding "Emerging Concern" Risk are of second most concern.

Scenario is Ranked by Plausibility (upper bound) with subranking by Belief (lower bound).

For Scenario CBRNE_5B, "likelihood" of exceeding "Emerging Concern" Risk is:
  Plausibility 1.0
  Belief 0

Y-axis: "Likelihood" of *Exceedance* for a Fuzzy Set (0 to 1)

X-axis: Fuzzy Set for Risk — Discretionary, Emerging Concern, High, Immediate

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Results of Ranking of All Five Scenarios

RANKING FOR SCENARIOS CBRNE_1B through CBRNE_5B

For *Exceeding* Fuzzy Set "High" the Scenarios rank ordered (decreasing) are:
    CBRNE_2B has plausibility of exceedance of 1.0 and belief of exceedance of 0.94
    CBRNE_3B has plausibility of exceedance of 1.0 and belief of exceedance of 0.77
    CBRNE_4B has plausibility of exceedance of 1.0 and belief of exceedance of 0.64
    CBRNE_1B has plausibility of exceedance of 0.5 and belief of exceedance of 0.0

For *Exceeding* Fuzzy Set "Emerging Concern" the Scenarios rank ordered (decreasing) (not already ranked for a worse fuzzy set) are:
    CBRNE_5B has plausibility of exceedance of 1.0 and belief of exceedance of 0.0

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Pooling Evidence
Four Experts Assign Evidence to Adversary Level of Technical Training

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PoolEvidence Tool

Pooled Evidence

Pooled Focal Elements for Selected Variable

Pooled Focal Elements for Variable: Adversary Estimate of Scientific/Engineering Expertise Required

```
POOLED FOCAL ELEMENTS FOR ALL EXPERTS
BS level, with Evidence: 1.35000e-01
BS level, advanced, with Evidence: 5.12500e-01
low level, BS level, advanced, with Evidence: 2.50000e-03
low level, BS level, with Evidence: 1.75000e-01
advanced, with Evidence: 1.75000e-01


FOCAL ELEMENTS FOR EACH EXPERT
Expert 1
   BS level, with Evidence: 4.00000e-01
   BS level, advanced, with Evidence: 6.00000e-01
Expert 2
   low level, BS level, advanced, with Evidence: 1.00000e-02
   BS level, with Evidence: 1.40000e-01
   BS level, advanced, with Evidence: 8.50000e-01
Expert 3
   low level, BS level, with Evidence: 4.00000e-01
   BS level, advanced, with Evidence: 6.00000e-01
Expert 4
   low level, BS level, with Evidence: 3.00000e-01
   advanced, with Evidence: 7.00000e-01
```

Close

Current Status/Capabilities

- **Operational**
  - **Maturity Level V**

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Vision

- **Future Capabilities**
  - **Integrate LinguisticBelief and PoolEvidence into One Package**
  - **Port to Server as Java Server Page for Use on Web**

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Customers

- **Applications to Date**
  - **DOE Nuclear Materials Site**
  - **International Terrorist Risk Model**
  - **DHS Planning Scenarios**
- **Future Applications**
  - **DOE Quantitative Uncertainty for Radiological Dispersal**
    - **Not a Terrorist Risk Problem**

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Funding History

- **FY 06**
  - **$50K Support for DOE Evaluation of Security at Nuclear Materials Site**
- **FY 07**
  - **$95K LDRD**
- **FY 08**
  - **$105K for Quantitative Evaluation of Radiological Dispersal**

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