



- **Evaluation of Risk of Intentional, Malevolent Acts**

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Risk

- Risk: combination of
 - Initiating event
 - System response
 - Consequence(s)
- Random Act
 - Initiating event not “designed” to maximize consequence
 - Earthquake magnitude independent of fragility of building

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Random Act

- Risk of random act
 - Estimate frequency and intensity of initiating event, then
 - Evaluate system response, then
 - Estimate consequence
 - Earthquake frequency and peak ground acceleration
 - Building response (fragility)
 - Consequence: deaths, injuries, economic loss

Intentional, Malevolent Act

- Initiating event: Threat
 - Adversary resources, attack plan
- System response: Vulnerability
- Consequence(s)
- Threat is not random, known to adversary
- Threat intentionally designed to cause maximum desired consequence within resources available to adversary based on adversary perception of vulnerability

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Risk of Intentional Act

- For each adversary
- First, consider consequence desired
- Then, consider resources available to adversary
- Then, develop threat scenarios and evaluate risk

For random act, first consider initiating event

**For intentional act first consider consequence
(Evaluate risk for intentional act “backwards” from risk for random act)**

Uncertainty in Risk of Intentional Act

- Threat (initiating event) is not random
 - Known to the adversary
 - Unknown to defender
- Uncertainty in Threat for the defender is not random (aleatory) but is state-of-knowledge (epistemic)
- Given the threat
 - Vulnerability known to defender, uncertain to adversary (epistemic uncertainty)

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Threat

- Variables comprising Threat are not numeric
 - Adversary Motivation
 - 1 to 10, 1 to 1000, ??
 - Unknown numeric scale
- Using forced numeric scale biases results
 - Combine Motivation with Resources
 - May Overweight motivation if scale 1 to 1000 instead of 1 to 10

Linguistic Variables

- Use linguistic variables
 - Consider Motivation as
 - Unwilling, Moderately Motivated, Highly Motivated

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Evaluation of Risk of Intentional Act

- Consider both adversary and defender
 - Each has different state of knowledge uncertainty
 - Adversary has uncertainty for Vulnerability
 - Defender has uncertainty for Threat
- Variables are linguistic not numeric

Evaluation of Risk of Intentional Act

- To address state of knowledge uncertainty use Belief/Plausibility measure of uncertainty
 - Extension of probability measure of uncertainty
 - Lower and upper bounds on probability
- To address linguistic variables use Fuzzy Sets and Approximate Reasoning

Evaluation of Risk of Intentional Act

- Sandia has a process and computer tools to evaluate risk of intentional acts
 - Subject Matter Experts (SMEs) develop adversaries, consequences and attack plans based on their State of Knowledge
 - SMEs identify variables, linguistic outcomes, and functional relationships using LinguisticBelief software
 - SMEs assign evidence to basic variables
 - Software estimates risk with uncertainty

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Notional Example

Rules for selected RuleLinguistic X

Rules for RuleLinguistic: Likelihood for Theft of Pu

Fuzzy Set for Input Linguistic: Threat	Fuzzy Set for Input Linguistic: Vulnerability	Output Fuzzy Set for Rule (blank if rule not set)
Remote	No	Unlikely
Remote	Maybe	Unlikely
Remote	Yes	Unlikely
Possible	No	Unlikely
Possible	Maybe	Marginal
Possible	Yes	Marginal
Expected	No	Unlikely
Expected	Maybe	Marginal
Expected	Yes	Likely

Specify Output Fuzzy Set for Selected Rule Choices Are: ▾

Accept Rules as Shown Cancel

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Notional Example

Rules for selected RuleLinguistic X

Rules for RuleLinguistic: Adversary Estimate Resources to Succeed

Fuzzy Set for Input Linguistic: Adversary Access	Fuzzy Set for Input Linguistic: Adversary Knowledge	Fuzzy Set for Input Linguistic: Adversary Tools	Output Fuzzy Set for Rule (blank if rule not set)
Limited	Limited	Poor	Unattainable
Limited	Limited	Moderate	Unattainable
Limited	Limited	Sophisticated	Unattainable
Limited	Marginal	Poor	Unattainable
Limited	Marginal	Moderate	Unattainable
Limited	Marginal	Sophisticated	Unattainable
Limited	Extensive	Poor	Unattainable
Limited	Extensive	Moderate	Unattainable
Limited	Extensive	Sophisticated	Unattainable
Some	Limited	Poor	Unattainable
Some	Limited	Moderate	Unattainable
Some	Limited	Sophisticated	Unattainable
Some	Marginal	Poor	Unattainable
Some	Marginal	Moderate	Possible
Some	Marginal	Sophisticated	Possible
Some	Extensive	Poor	Unattainable
Some	Extensive	Moderate	Possible
Some	Extensive	Sophisticated	Possible
Extensive	Limited	Poor	Unattainable
Extensive	Limited	Moderate	Possible
Extensive	Limited	Sophisticated	Possible
Extensive	Marginal	Poor	Unattainable
Extensive	Marginal	Moderate	Possible
Extensive	Marginal	Sophisticated	Possible
Extensive	Extensive	Poor	Unattainable
Extensive	Extensive	Moderate	Possible
Extensive	Extensive	Sophisticated	Attainable

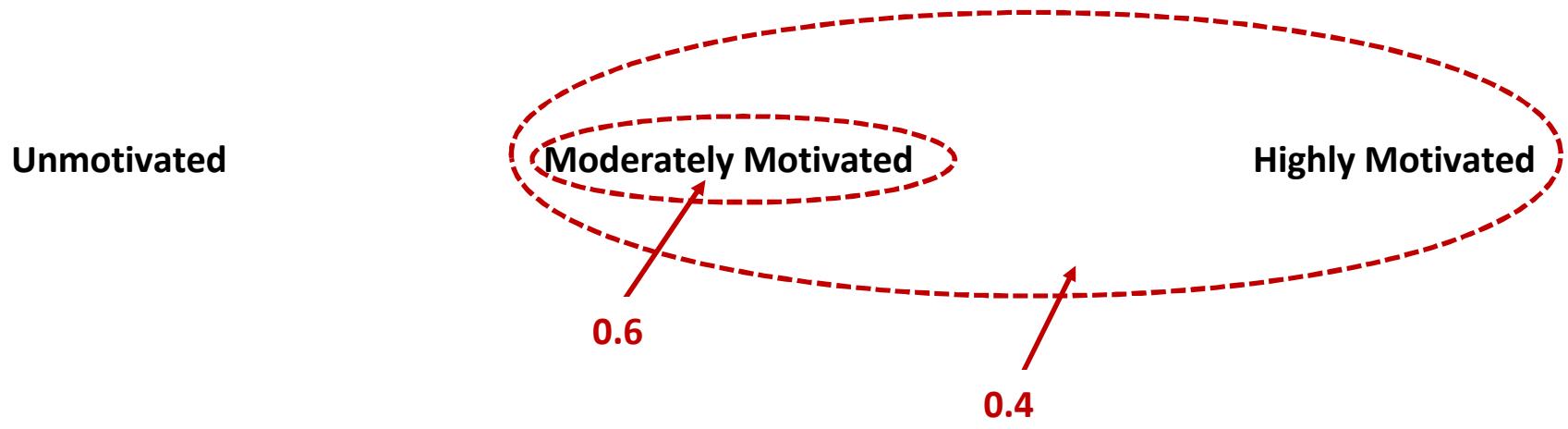
Specify Output Fuzzy Set for Selected Rule Choices Are: ▾

Accept Rules as Shown Cancel

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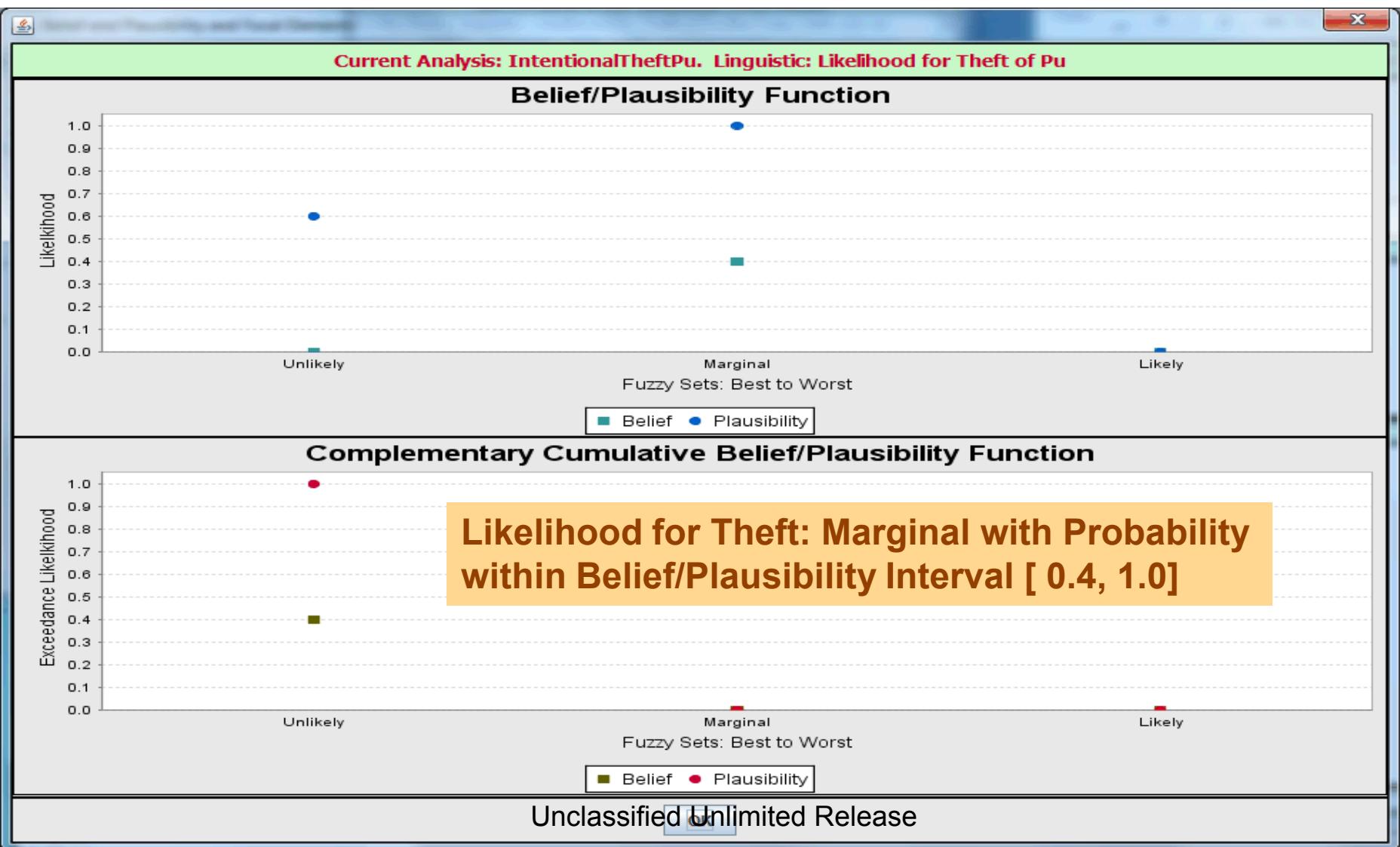
Notional Example

Evidence for Adversary Motivation



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Notional Example



Ranking Results

- Rank by worst outcome with non-zero plausibility
 - For equal plausibility rank by highest belief

Adversary	Worst Risk Outcome with Non-Zero Plausibility and Belief/Plausibility Interval for that Outcome	Rank
Adv A	Marginal [0.4, 1.0]	3
Adv B	Likely [0.02, 0.08]	1
Adv C	Unlikely [0.4, 0.6]	5
Adv D	Marginal [0.12, 0.34]	4
Adv E	Marginal [0.7, 1.0]	2

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Applications

- Terrorist acts
- NEA trust
- Use Control

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