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Risk Assessment Methodology Applied to C-IED R&D Portfolio Prioritization

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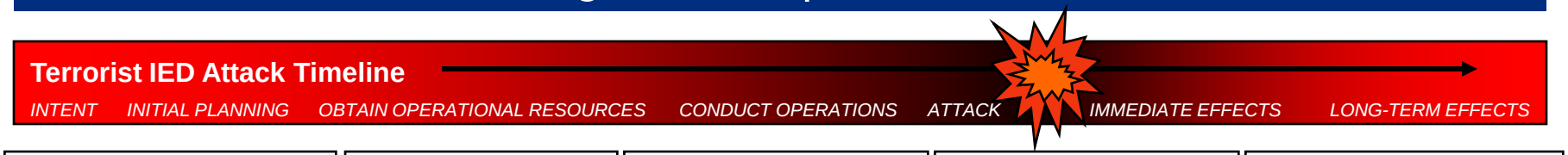
Outline

- Define the problem
- Goals and contributions
- Analysis strategies
- ELM model introduction
- INFTree model introduction
- Status
- Conclusions

DHS S&T Counter-IED Program

DHS S&T has established a counter-IED program to leverage existing multi-agency research and investments to deter, predict, detect, defeat and mitigate the impact of IED attacks



Deter

Human Factors

- Actionable Indicators
  - Group Characteristics
  - Pre-incident Rhetoric
  - *Pre-incident Behaviors*
  - Community Characteristics
  - *Integration*
- Countermeasures
  - Comparative Counter Red/IED Strategies
  - *Strategy Impact*

Predict

Human Factors

- Predictive Screening
  - Behavior Analysis
  - Video Tracking
  - Video Identification & Alert
- *Risk Prediction*
  - *Target Prediction*
  - *Staging Area Prediction*

Detect

Explosives

- Person Borne IED Detection
- Vehicle Borne IED Detection
- *Canine/Biological*
- *Marking*

Defeat

Explosives

- Bomb Assessment/ Diagnostics
  - Type of Explosive
  - Device Triggers
- Render Safe
  - Electronic Countermeasures (IR/RF Jamming)
  - *Directed Energy*
- *Robotics*
- *Bomb Components*

Mitigate

Infrastructure

- Blast Mitigation
  - Affordable blast resistant materials
  - Rapidly stabilize damaged structure

Explosives

- *Body Armor*
- Inerting
- *Tagging (Forensics)*
- *Post Blast (Forensics)*

Cross Cutting:

***Standards; Outreach*; Technology Demonstration/ System Integration**

Intel Data Sharing (FBI, CIA, DIA); Technology resource & Test sharing (DoJ, DoD, DoE)

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Define The Problem

- The DHS S&T portfolio is very complicated and changing
- DHS S&T would like some “risk based” process for making funding decisions
- Need a way to compare very different technology types
  - social modeling
  - a new detector
  - post blast mitigation

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The Goal

- To provide a tool that helps policy makers prioritize their portfolio

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Our Contribution

- We have produced a methodology that allows us to evaluate a new “quad chart” and rank it, compared to all other quad charts across divisions
- Technical internals:
  - Couples a logic model with an evidential reasoning model
  - Takes an Excel spreadsheet containing weights of the subjective merits of different technologies as input
  - Produces an Excel spreadsheet containing the aggregate rankings of the different technologies as output
  - ELM for the logic model
  - INFTree for the evidential reasoning model

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Funding Analysis Strategy Considerations

- Need a common basis for comparison
  - Dollars (numeric)
  - Attractiveness (linguistic)
- Two alternatives
  - Probabilistic
  - Degrees of belief

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Cost Benefit Analysis Considerations

- Cost benefit analysis is a simple matter of determining
  - Likelihood that a technology can be matured into something useful
  - Cost to mature
  - Cost to deploy
    - Direct and indirect
  - "Increase in efficiency"
    - Probability of detection
    - Decrease in the number of possible events for any analyst to study
  - Value of saved target (benefit)
- "The REALLY Big Problem"
  - **We don't know any of these numbers with any kind of certainty**
  - You can get any answer you want
  - You need to maintain consistency between different technologies
  - How do you value information?
    - HE properties
    - Understanding the process of radicalization?

Evidential Reasoning Strategy

- It is much easier and more defensible to assign “degrees of belief” than factual numbers
  - $ cost versus “Very Expensive”
  - 32% chance of success versus “Unlikely”
- With evidential reasoning we are effectively computing over binned quantities
  - Certain, Nearly Certain, Likely, Unlikely, Negligible
  - Very Expensive, Expensive, Moderate, Cheap, Negligible
- Determine factors to be included in the analysis
- Determine the order to combine factors
- Define rule bases to combine factors
- Map technologies onto the factors
- Problems
  - Utterly subjective (but at least it is subjectively consistent)
  - Imprecise (“what do you mean by…?”)
  - Can still get any answer you want

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ELM Model Introduction

- Extensible Logic Modeling
- ELM is a framework, more than just a piece of software
- ELM application is in-house software used for creating programmable logic trees
- Trees composed of “and” and “or” gates represent complex decision logic
- Customizable to a problem
- Programmable analysis

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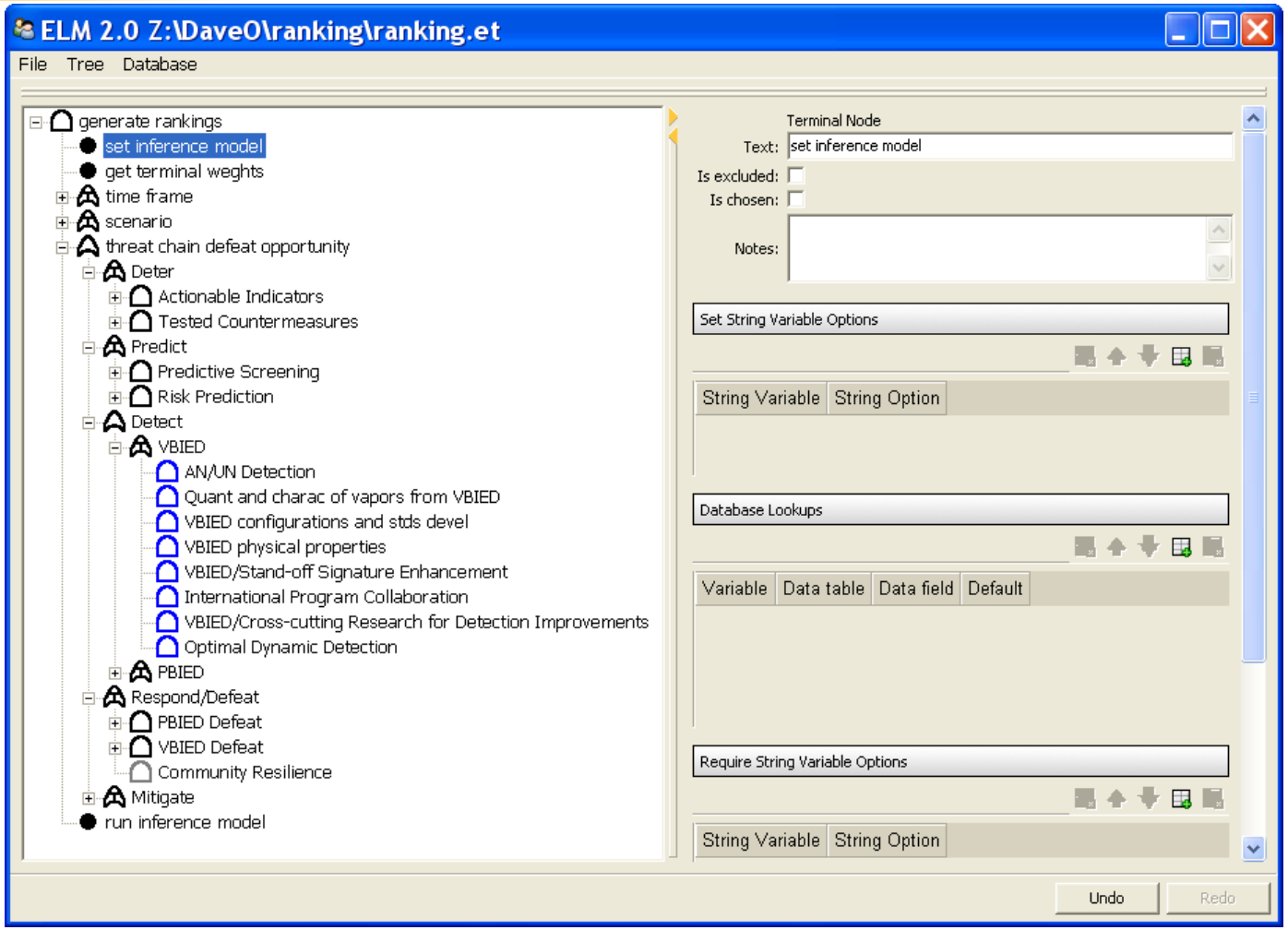
ELM Screen Shot



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In Practice, ELM trees are used to

- Capture “corporate knowledge”
- Manage possibilities and complexity
- Represent complex decision processes
- Analyze problems with conditional and customizable algorithms and data

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Evidential Reasoning Model Introduction

- INFTree is in-house software for developing evidential reasoning models
- Our model depends on the following eight factors:
  - How easy is the technology to develop?
  - How expensive is the technology to develop?
  - How easy is the technology to deploy?
  - How expensive is the technology to deploy (direct and indirect)?
  - How effective is the technology towards its goal?
  - How defeatable is the technology?
  - How important is the goal?
- The last factor is important as it can be used to indicate political necessity or quantify the value of information
- Need to map each technology onto these factors using elicitation

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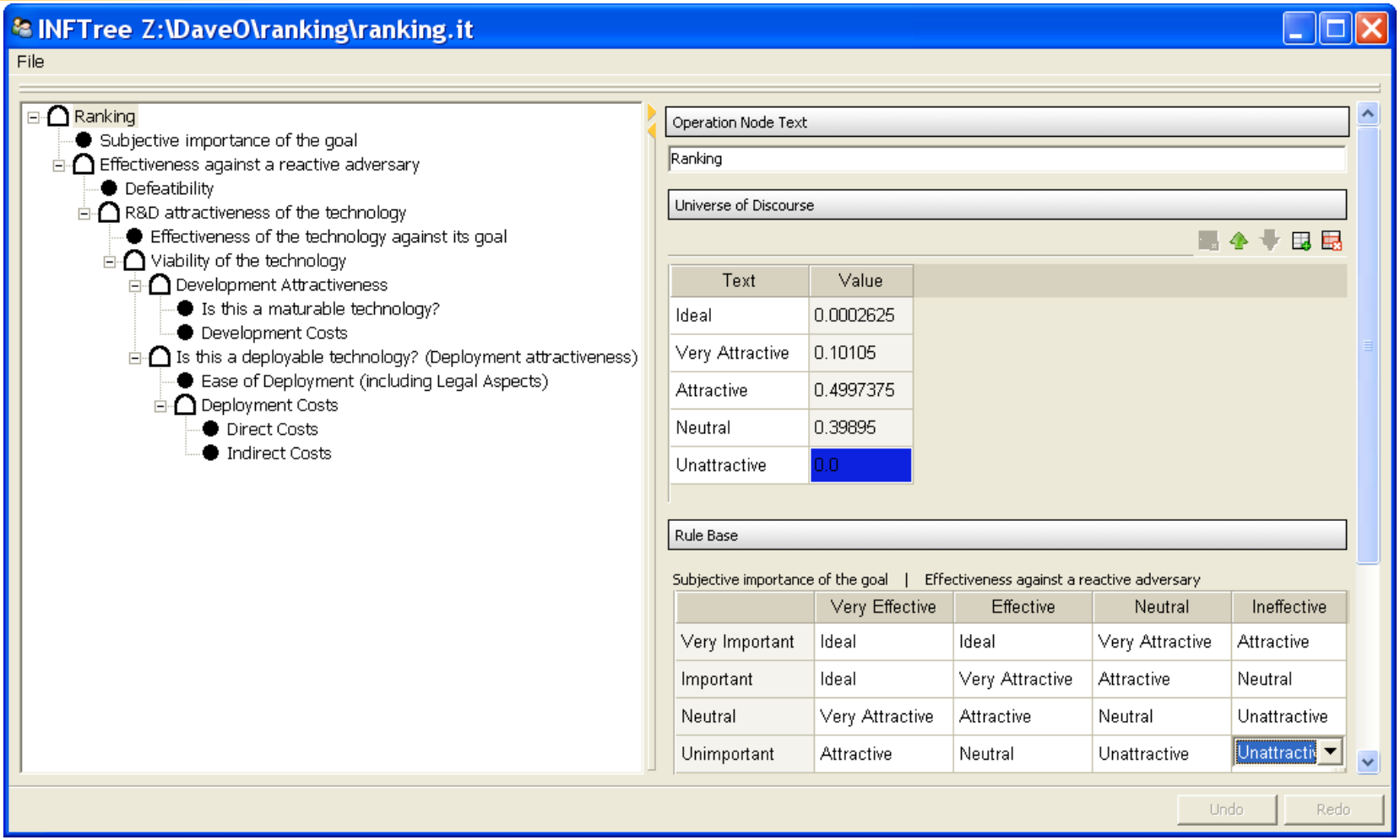
The INFTree Model



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Sample Input (Excel)

	A	B	C	D	E	F	G	H	I	J	K	L
1	Technology	Time Frame	Scenario	Subjective importance of the goal				Defeatibility				
2				Very Important	Important	Neutral	Unimportant	Nearly Certain	Likely	Neutral	Unlikely	Negligible
3	Actionable Indicators	current	base	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
4	Tested Countermeasures	current	base	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
5	Predictive Screening	current	base	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
6	Risk Prediction	current	base	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
7	AN/UN Detection	current	base	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	Quant and charac of vapors from VBIED	current	base	0.90	0.10	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	VBIED configurations and stds devel	current	base	0.40	0.60	0.00	0.00	0.00	0.00	0.00	1.00	0.00
10	VBIED physical properties	current	base	0.30	0.70	0.00	0.00	0.00	0.00	0.00	1.00	0.00
11	VBIED/Stand-off Signature Enhancement	current	base	0.20	0.80	0.00	0.00	0.00	0.00	0.00	1.00	0.00
12	International Program Collaboration	current	base	0.00	0.80	0.20	0.00	0.00	0.00	0.00	1.00	0.00

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Sample Output (Excel)

	D	E	F	G	H	I	J	K
1	technology	Ranking					Centroid of Ranking	Uncertainty of Ranking
2		Ideal	Very Attractive	Attractive	Neutral	Unattractive		
3	AN/UN Detection	1	0	0	0	0	162	0
4	PBIED Defeat	1	0	0	0	0	162	0
5	VBIED Defeat	1	0	0	0	0	162	0
6	Blast-resistant materials	1	0	0	0	0	162	0
7	Quant and charac of vapors from VBIED	0.81	0.18	0.01	0	0	141.12	0.504527615
8	Blast Vulnerability and Mitigation	0.81	0.18	0.01	0	0	141.12	0.504527615
9	PBIED/Multi-spectral imaging	0.64	0.32	0.04	0	0	121.68	0.583312355
10	Rapid Structural Stabilization	0.64	0.32	0.04	0	0	121.68	0.583312355
11	Actionable Indicators	0.5	0.5	0	0	0	108	0.430676558
12	Predictive Screening	0.5	0.5	0	0	0	108	0.430676558
13	PBIED/Multispectral detection	0.49	0.42	0.09	0	0	103.68	0.630412351
14	Preventing Structural Collapse from IED Attacks	0.49	0.42	0.09	0	0	103.68	0.630412351
15	Multimodal trace: Materials for Improved Explosive Trace De	0.36	0.48	0.16	0	0	87.12	0.656106383
16	Multimodal trace: Orthogonal MEMS Sensor Arrays	0.36	0.48	0.16	0	0	87.12	0.656106383
17	Multimodal trace: Novel Adsorber-Susceptor Preconcentrat	0.36	0.48	0.16	0	0	87.12	0.656106383
18	Multimodal trace: Single Carbon Nanotube Chemical Sensc	0.36	0.48	0.16	0	0	87.12	0.656106383
19	Multimodal trace: Trace Detection of RDX, PETN and Perox	0.36	0.48	0.16	0	0	87.12	0.656106383
20	Multimodal trace: Electronic Detection of Explosives Using	0.36	0.48	0.16	0	0	87.12	0.656106383

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Status

- The model runs end-to-end and can be used to evaluate all, currently 33, technologies against each other
- Decision maker input (elicitation) is critical as the result will (and should) reflect their beliefs and preferences
  - Results are subjective, but consistently so
- The model can be used to run what if scenarios or perspectives
  - Emphasis on information gathering
  - Emphasis on deployable technologies
  - Etc.
- Can be run with differing time frames (near term benefit versus long term benefit)

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Conclusions

- We have developed a model using ELM and INFTree that combines logic trees and evidential reasoning techniques to help DHS S&T prioritize their portfolio
- We believe we have developed a useful framework that is easily extendable to new technologies and areas
- This model is operational and interactive