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Risk Assessment Methodology applied to Counter IED Research & Development Portfolio Prioritization

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ABSTRACT

In an effort to protect the United States from the ever increasing threat of domestic terrorism, the Department of Homeland Security, Science and Technology Directorate (DHS S&T), has significantly increased research activities to counter the terrorist use of explosives. More over, DHS S&T has established a robust Counter-Improvised Explosive Device (C-IED) Program to Deter, Predict, Detect, Defeat, and Mitigate this imminent threat to the Homeland. The DHS S&T portfolio is complicated and changing. In order to provide the "best answer" for the available resources, DHS S&T would like some "risk based" process for making funding decisions. There is a definite need for a methodology to compare very different types of technologies on a common basis. A methodology was developed that allows users to evaluate a new "quad chart" and rank it, compared to all other quad charts across S&T divisions. It couples a logic model with an evidential reasoning model using an Excel spreadsheet containing weights of the subjective merits of different technologies. The methodology produces an Excel spreadsheet containing the aggregate rankings of the different technologies. It uses Extensible Logic Modeling (ELM) for logic models combined with LANL software called INFTree for evidential reasoning.

Keywords: evidential reasoning, C-IED, Counter-Improvised Explosive Device, risk based decisions, risk assessment, portfolio prioritization, logic models, cost benefit analysis, Extensible Logic Modeling, ELM

1 INTRODUCTION

The Department of Homeland Security (DHS) plays a major role in fulfilling Presidential Directive/HSPD-19 (Combating Terrorist Use of Explosives in the United States) including national policies, strategies and implementation plans for the prevention and detection of, protection against and response to terrorist use of explosives in the United States.

Terrorists have repeatedly shown their willingness and ability to use explosives as weapons worldwide and there is ample intelligence to support the conclusion that they will continue to use such devices to inflict harm. The threat of explosive attacks in the United States is of great concern considering terrorists' ability to make, obtain, and use explosives, the ready availability of components used in IED construction, the relative technological ease with which an IED can be fashioned and the nature of our free society.

It is the policy of the United States Government to counter the threat of explosive attacks aggressively by coordinating Federal, state, local, territorial, and tribal government efforts and collaborating with the owners and operators of critical infrastructure and key resources to deter, prevent, detect, protect against and respond to explosive attacks, including the following:

(a) Apply techniques of psychological and behavioral sciences, such as social network theory, in the analysis of potential threats of explosive attack;

(b) Use the most effective technologies, capabilities, and explosives search procedures and applications to detect, locate and render safe explosives before they detonate or function as part of an explosive attack, including detection of explosive materials and precursor chemicals used to make improvised explosive or incendiary mixtures;

(c) Apply all appropriate resources to pre-blast or pre-functioning search and render-safe procedures, and to post-blast or post-functioning investigatory and search activities, in order to detect secondary and tertiary explosives and for the purposes of attribution;

(d) Employ effective capabilities, technologies and methodologies, including blast mitigation techniques, to mitigate or neutralize the physical effects of an explosive attack on human life, critical infrastructure, and key resources; and

(e) Clarify specific roles and responsibilities of agencies and heads of agencies through all phases of incident management from prevention and protection through response and recovery.

In an effort to protect the United States from the ever increasing threat of domestic terrorism, the Department of Homeland Security, Science and Technology Directorate (DHS S&T), has significantly increased research activities to counter the terrorist use of explosives. More over, DHS S&T has established a robust Counter-Improvised Explosive Device (C-IED) Program to Deter, Predict, Detect, Defeat, and Mitigate this imminent threat to the Homeland. The IED threat, whether deployed by as a suicide vest or Vehicle-Borne IED, presents the analytical community with many unique challenges.

There is no single technology solution to counter the threat of an attack by an improvised explosive device (IED). For this reason, the Counter-IED Program has taken a layered systems approach and is developing technology solutions that can be injected at each stage in the IED attack timeline.

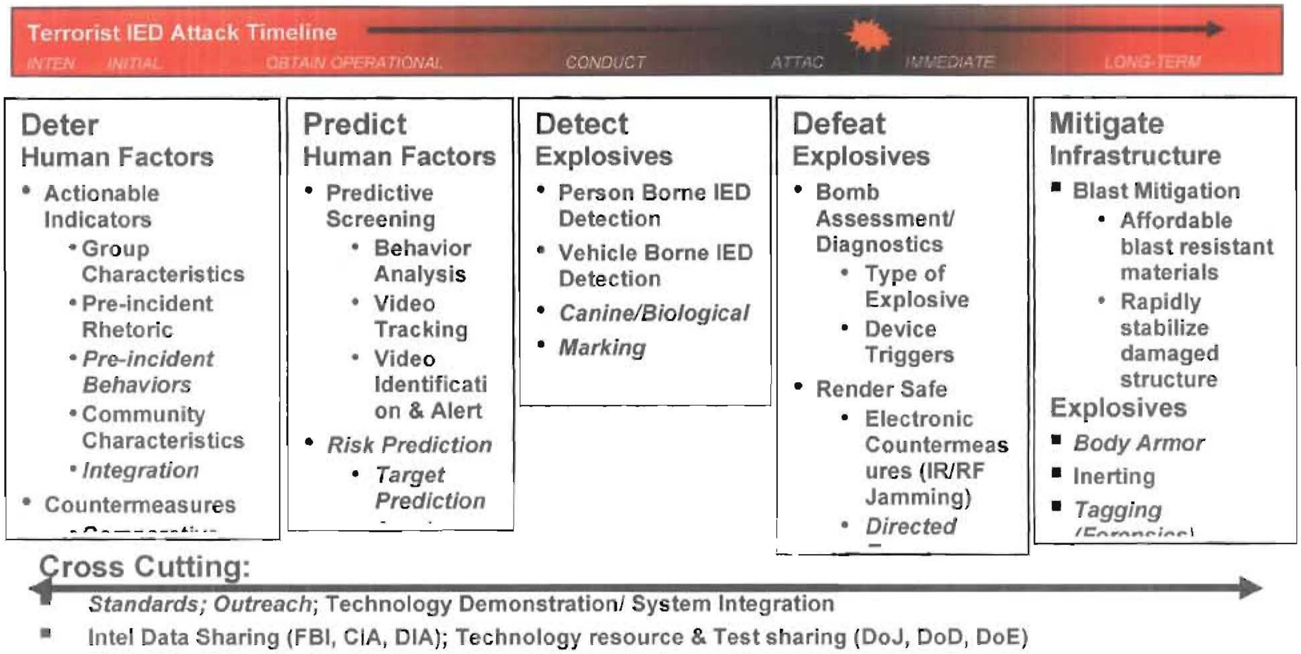

Figure 1. IED Attack Sequence

This has lead to the DHS Counter-IED Program to examine some required capability needs. As an example, some representative needs are:

- Capability to identify and model the human precursors of IED threats and terrorist activity within CONUS using unstructured data and novel computational models
- Capability to predict participants and locations of potential IED attacks based on existing or known geospatial, socio-cultural, and behavioral information
- Capability to non-intrusively detect vehicle-borne IEDs—in particular, technologies to detect the explosive or explosive device
- Capability to detect person-borne IEDs from a standoff distance—in particular, technologies to detect the explosive or explosive device
- Capability to defeat vehicle-borne IEDs—in particular, non-explosive and standoff defeat technologies
- Capability to defeat person-borne and leave-behind IEDs
- Capability to diagnose vehicle-borne and person-borne IEDs
- Capability to diagnose and defeat water-borne IEDs, above and below the waterline
- Capability to characterize IED threats, including IED design, assembly, detonation, and effects

The DHS S&T portfolio is complicated and changing. In order to provide the "best answer" for the available resources, DHS S&T would like some "risk based" process for making funding decisions. There is a definite need for a methodology to compare different types of technologies such as social modeling, a new detector, or post blast mitigation on a common basis. Ultimately, the goal is to provide a tool that helps policy makers prioritize their portfolio.

2 METHOD

A funding analysis strategy needs to provide a common basis for comparison such as Dollars (numeric) or Attractiveness (linguistic). There are two alternatives to doing the comparison: 1) Probabilistic or 2) Degrees of belief. A methodology was developed that allows users to evaluate a new "quad chart" and rank it, compared to all other quad charts across S&T divisions. It couples a logic model with an evidential reasoning model using an Excel spreadsheet containing weights of the subjective merits of different technologies. The methodology produces an Excel spreadsheet containing the aggregate rankings of the different technologies. It uses Extensible Logic Modeling (ELM) for logic models combined with a LANL software called INFTree for evidential reasoning.

Cost benefit analysis is a simple matter of determining factors like the following:

- 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 problem, of course, is that we don't know these numbers with any kind of certainty. Further, you need to maintain consistency between different technologies. Finally, the question arises of how do you value different kinds of information such as HE properties or an understanding of the process of radicalization?

With an Evidential reasoning (ER) strategy, though, it is much easier and more defensible to assign "degrees of belief" than factual numbers such as dollar cost versus "Very Expensive" or a 32% chance of success versus "Unlikely". With ER we are effectively computing over binned quantities like:

- Certain, Nearly Certain, Likely, Unlikely, Negligible
- Very Expensive, Expensive, Moderate, Cheap, Negligible

The strategy starts with determining factors to be included in the analysis. Then, the order to combine factors is determined. Next, rule bases to combine factors are defined. Finally, the technologies are mapped onto the factors. However, the problem is that this is still subjective, imprecise, and you can still get any answer you want.

The solution is a combination of Cost benefit analysis and Evidential reasoning using Extensible Logic Modeling (ELM). ELM is a framework, more than just a piece of software. The ELM application is a Los Alamos National Laboratory (LANL) software used for creating programmable logic trees. The trees are composed of "and" and "or" gates representing complex decision logic. It is customizable to a problem and provides programmable analysis.

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.

Finally, INFTree is a LANL software for developing Evidential reasoning models. It is used with ELM to provide a consistent model for ranking technologies articulated in the ELM tree.

3 RESULTS

The ELM tree developed for this analysis is shown in Figure 2. It shows the 5 areas of concern for the attack timeline listed in Figure 1. The expanded Detect branch shows sample Vehicle Bourne IED (VBIED) technologies under consideration by the Counter-IED Program.

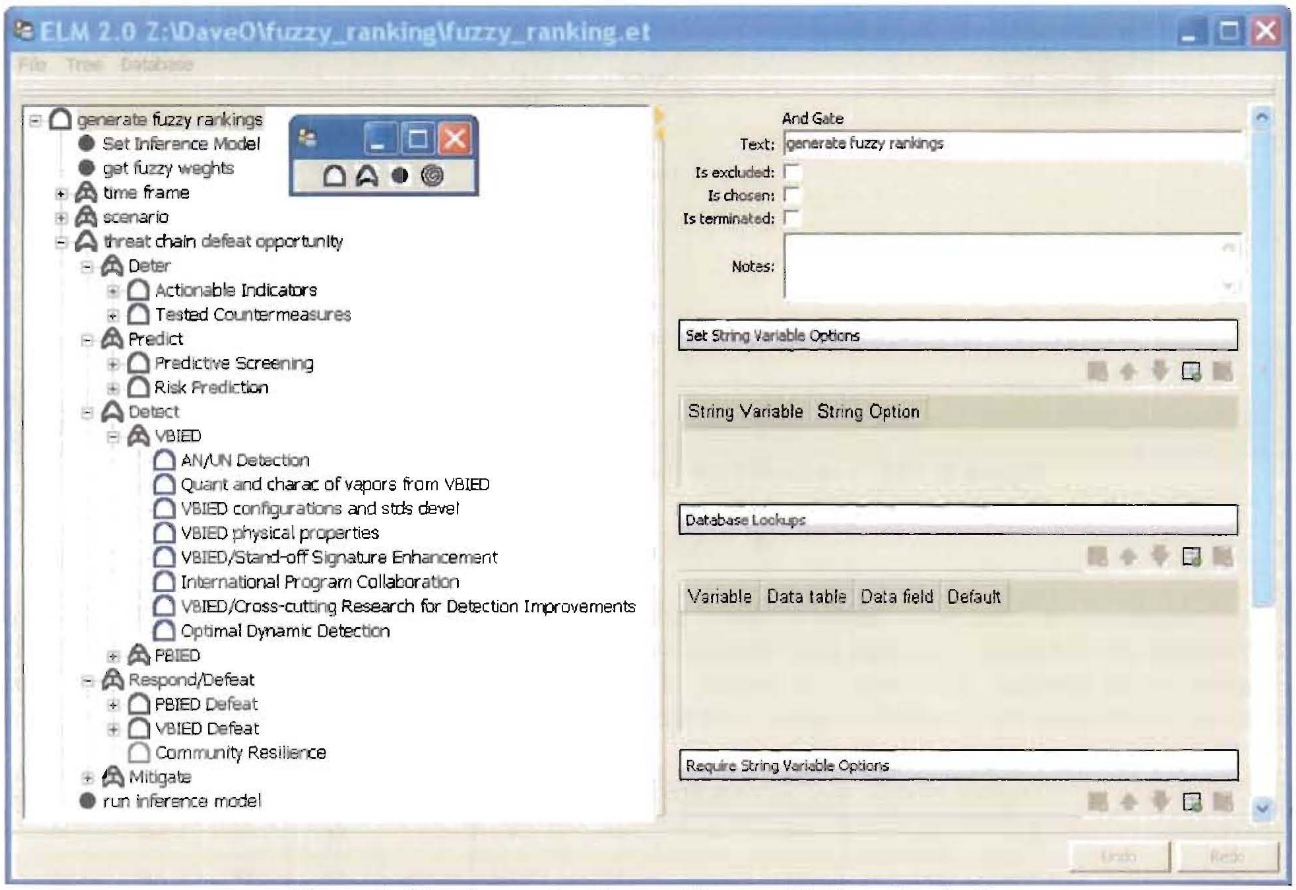

Figure 2. Elm tree using for ranking multiple technologies.

The INFTree model, shown in Figure 3, depends on the following eight factors:

1. How easy is the technology to develop?
2. How expensive is the technology to develop?
3. How easy is the technology to deploy?
4. How expensive is the technology to deploy (direct and indirect)?
5. How effective is the technology towards its goal?
6. How defeatable is the technology?
7. 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. Then, each technology is mapped onto these factors using elicitation.

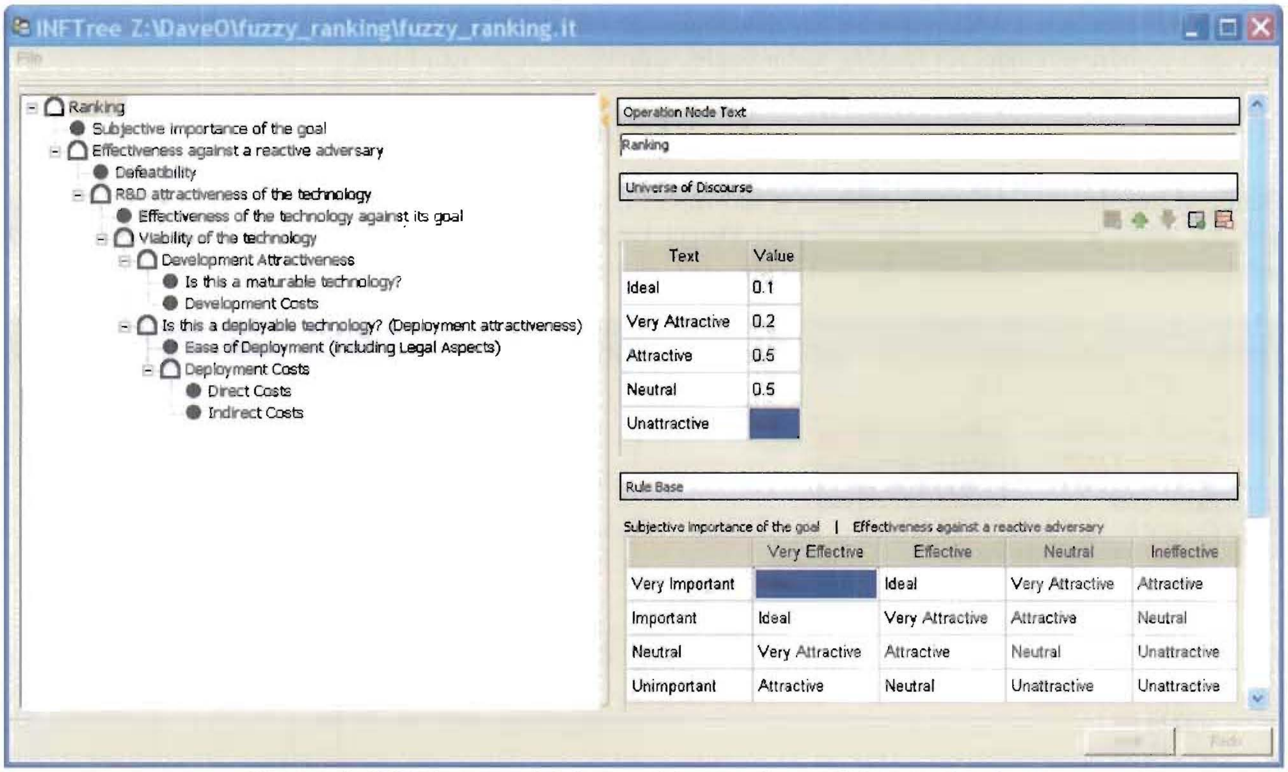

Figure 3. INFTree model for ranking each candidate technology

4 ANALYSIS

For this analysis, an input table (using an Excel spreadsheet) was generated using place holding data to demonstrate the technique. In actual use, program managers and analysts with the DHS S&T Counter-IED Program would generate the values. A portion of the table is shown in Figure 4, listing some of the technologies and answers to two of the question in the INFTree model shown in Figure 3.

	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

Figure 4. Portion of sample input table (Excel).

In Figure 5 are shown the results of the analysis using the sample input table, basically ranking each technology from most attractive to least.

	D	E	F	G	H	I	J	K
1	technology	Ranking					Centroid of Ranking	Uncertainty of Ranking
2		Ideal	Very Attracti	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	0.48589561
8	Blast Vulnerability and Mitigation	0.81	0.18	0.01	0	0	141.12	0.48589561
9	PBIED/Multi-spectral imaging	0.64	0.32	0.04	0	0	121.68	0.56177086
10	Rapid Structural Stabilization	0.64	0.32	0.04	0	0	121.68	0.56177086
11	Actionable Indicators	0.5	0.5	0	0	0	108	0.41477184
12	Predictive Screening	0.5	0.5	0	0	0	108	0.41477184
13	PBIED/Multispectral detection	0.49	0.42	0.09	0	0	103.68	0.60713147
14	Preventing Structural Collapse from IED Attacks	0.49	0.42	0.09	0	0	103.68	0.60713147
15	Multimodal trace: Materials for Improved Explosive T	0.36	0.48	0.16	0	0	87.12	0.63187663
16	Multimodal trace: Orthogonal MEMS Sensor Arrays	0.36	0.48	0.16	0	0	87.12	0.63187663
17	Multimodal trace: Novel Adsorber-Susceptor Precon	0.36	0.48	0.16	0	0	87.12	0.63187663
18	Multimodal trace: Single Carbon Nanotube Chemica	0.36	0.48	0.16	0	0	87.12	0.63187663
19	Multimodal trace: Trace Detection of RDX, PETN an	0.36	0.48	0.16	0	0	87.12	0.63187663
20	Multimodal trace: Electronic Detection of Explosives	0.36	0.48	0.16	0	0	87.12	0.63187663
21	Multimodal trace: Au-Thiolate Nanoparticles as Inter	0.36	0.48	0.16	0	0	87.12	0.63187663
22	Effective Risk Communications Against the IED Thre	0.36	0.48	0.16	0	0	87.12	0.63187663
23	PBIED Threat Characterization	0.25	0.5	0.25	0	0	72	0.63977779
24	VBIED configurations and stds devel	0.16	0.48	0.36	0	0	58.32	0.63187663

5 CONCLUSIONS

The model runs end-to-end and can be used to evaluate all, currently 33, technologies against each other. In addition, the model can be used to run what if scenarios or perspectives, potentially emphasizing items such as information gathering, deployable technologies, or others of interest. It can be run with differing time frames to look at near term benefit versus long term benefit. Finally, the model is an interactive capability, so it should be used by or with decision makers to capture their current strategies.

NOMENCLATURE

DHS	Department of Homeland Security
ELM	Extensible Logic Modeling
IED	Improvised Explosive Device
S&T	Science and Technology

REFERENCES

Protacio, M., "Predictive Modeling for Counter-Improvised Explosive Devices", DHS Commercialization Office - Pilot Operational Requirements Document, February 2009

Walker, S., et al, "High Priority Technology Needs", Homeland Security Science and Technology, Ver. 3, May 2009

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