

Advanced Risk and Decision Analysis
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1. Overview

In Year 4, the major research accomplishments in advanced risk and decision analysis were:

- Developing and testing advanced techniques and associated software to elicit threat judgments by intelligence analysts
- Identifying and structuring terrorists’ objectives as inputs to threat assessments
- Merging extended forms of games with adaptive decision tree approaches to modeling terrorists’ responses to our defensive actions
- Continuation of the experimental use of project management tools and “attack trees” to model terrorist plans and the evolution of specific attacks
- Exploration of behavioral approaches to model terrorism risks and public responses to them

2. Research Accomplishments

Many threat assessments require the elicitation of (relative) frequencies or likelihoods of terrorist events in the form of “split fractions,” a distribution over a discrete set of mutually exclusive and exhaustive events (e.g., the type of nuclear device used by terrorists). The state of the art of eliciting split fractions has not much improved since the nineteen-seventies, when Spetzler and von Holstein wrote their seminal article on expert elicitation). In our work with Stephen Hora, we made significant advances by using specific families of probability distributions (multinomial, beta, and Dirichlet distributions) to provide the theoretical underpinning of these elicitations (Hora and von Winterfeldt, 2008). We also developed two software programs (Eppel, 2008a and b) to assist in eliciting these distributions in practice. The theory and techniques were tested with several elicitation with intelligence analysts, which are described in the task on applied decision analysis.

In previous years we had developed advanced and still experimental methods to model the terrorists’ utilities for alternative modes and targets of attack and to model their perceptions of the likelihood of success of these alternative attacks. This results in an expected utility model as seen from the perspective of terrorists that can be used to infer the relative probability of choosing one attack mode over another. In Year 4 we went one step further and developed a more realistic set of objectives for Al Qaeda, using written, videotaped and e-mail statements by Al Qaeda leaders and their ideological fathers (Keeney, 2008). We also developed means-ends networks and differentiated between means, ends, strategic and fundamental objectives as is common in decision analysis.

Previous work on adaptive and dynamic decision trees (von Winterfeldt and O’Sullivan, 2006) modeled terrorist acts as events with probability distributions that depend on our defensive actions. This modeling

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approach can account for deterrence effects as well as for effects of improved prevention, protection, and response and recovery. This approach was extended in Year 4 to more complex decision trees (Garcia and von Winterfeldt, 2008). The use of adaptive and dynamic decision trees is a midway between the static modeling pursued by some groups (e.g., the Bioterrorism Risk Assessment studies conducted by the Battelle National Biodefense Institute or BNBI) and the stochastic or dynamic game theoretic approaches pursued at CREATE and elsewhere (see the work by Kardes and Bazir elsewhere in this report). Static approaches based on a simplistic application of probabilistic risk analysis (PRA) have been criticized recently by the National Academy of Sciences and others. Ezell and von Winterfeldt (2008), in a note to the National Academies defended the limited use of static approaches, while recognizing the need for more dynamic, stochastic, and adaptive approaches.

In previous years, we developed a project risk analysis tool for vulnerability analysis (Rosoff and von Winterfeldt, 2007). This tool consists of two parts: A standard project analysis, using Microsoft project and a risk analysis part using @Risk for Microsoft Project. Microsoft Project is used to map out an attack as a complex project, like any other business or government project. @Risk for Microsoft Project is used to identify those parts of the project that are likely to fail, due to interdiction by intelligence and policy efforts as well as to security measures at the attack site. This tool was successfully applied in the analysis of a dirty bomb attack on the Los Angeles and Long Beach harbors. In Year 4 we developed the same tool in the context of an explosives attack using TATP on transportation targets to support an ongoing CBP tabletop exercise.

For some years now we have believed that much could be learned from experimental games and behavioral economics to shed light on both defender and attacker interactions. We also believed that much can be learned from behavioral economics to predict public responses to terrorist events (e.g., avoiding to fly after attacks on planes), which can have devastating effects on the economy. To investigate the value of behavioral economics and experimental games for terrorism research, we conducted a workshop in August of 2008, which included some of the best economists and psychologists working in this area. Kunreuther and von Winterfeldt (2008) provide a brief summary and a research agenda.

3. Applied Relevance

This project focuses on the development of advanced decision and risk analysis tools and as such, we there is limited immediate applied relevance. However, some of the tools (e.g., the Dirichlet elicitation tools) have been applied in test settings and others, like the use of adaptive and dynamic decision trees, have shown significant applied potential.

4. Collaborative Projects

Within CREATE, this project was closely related to the applied decision analysis project and to the risk perception project. It also contributed in the design of an inter-center project on “Understanding Risk Perception and Improving Risk Communication,” funded by Battelle PNNL in October of 2008. Furthermore, the expert elicitation project was closely associated with work at BNBI on bioterrorism, the work on WMD threat assessments at the Science and Technology Directorate of the DHS, and the development of the “Risk Analysis Process for Informed Decision making” (RAPID) at the Risk Management and Assessment Office of DHS.

5. Research Products

Research Products (Please detail below)		#
5a	# of peer-reviewed journal reports published	2
5a	# of peer-reviewed journal reports accepted for publication	1
5a	# of non-peer reviewed publications and reports	6
5a	# of scholarly journal citations of published reports	?
5b	# of scholarly presentations (conferences, workshops, seminars)	15
5b	# of outreach presentations (non-technical groups, general public)	8
5c	# of products delivered to DHS, other Federal agencies, or State/Local	2
5c	# of patents filed	0
5c	# of patents issued	0
5c	# of products in commercialization pipeline (products not yet to market)	0
5c	# of products introduced to market	0

5.1. Publications and Reports

	Ref	Not Ref
1. von Winterfeldt, D., "Structuring Problems for Decision Analysis: Concepts, Tools, and an Example," <i>European Journal of Operational Research</i> , forthcoming, 2008	x	
2. Eppel, T., von Winterfeldt, D., "Value of Information Analysis for Nuclear Waste Storage Tanks," <i>Decision Analysis</i> , 3, 157-167, 2008	x	
3. Eppel, T., "Manual for the Dirichlet Elicitation Tool," <i>CREATE Report</i> , 2008		x
4. Eppel, T., "Manual for the Dirichlet Aggregation Tool," <i>CREATE Report</i> , 2008		x
5. Garcia, M., von Winterfeldt, D., "Modeling Terrorist Attacks with Dynamic and Adaptive Decision Trees: An Application to MANPADS Countermeasures," draft <i>CREATE Report</i> , 2008		x
6. Hora, S., von Winterfeldt, D., "Eliciting Split Fractions with Dirichlet Distributions," draft <i>CREATE Report</i> , 2008		x
7. Keeney, G., von Winterfeldt, D., "Al Qaeda's Values and Objectives," draft <i>CREATE Report</i> , 2008		x
8. Southwell, C., von Winterfeldt, D., "A Decision Analysis of Options to Rebuild the New Orleans Levee System," in Richardson, H., Gordon, P., Moore II, J. (eds.) <i>Risk and Economic Impacts of Hurricane Katrina</i> , London: Elgar, 34-52, 2008		x
9. Kavet, R., Mohan, M., von Winterfeldt, D., "A New Paradigm for Assessing the Value of Environmental Research," submitted to <i>Decision Analysis</i> , 2008	x	
10. von Winterfeldt, D., note on the review of the Risk Assessment for Informed Decision making (RAPID) methodology, submitted to the Risk Management and Analysis Division, DHS, 2008		

5.2. Presentations

Conferences

- von Winterfeldt, D., "Intelligence Analysis Tasks - Risk Analysis Tools," *Intelligence and Risk Analysis Symposium*, sponsored by CREATE, HSI, and CPASS, Georgetown University, Washington, DC, December 16, 2008

- von Winterfeldt, D., “Decision Analysis with Multiple Stakeholders,” *ISEE Conference 2008*, Pasadena, CA, October 13, 2008
- von Winterfeldt, D. “Should we Protect Commercial Airplanes against Surface to Missile Attacks by Terrorists?,” *INFORMS National Meeting*, October 12, 2008
- von Winterfeldt, D., “Need for Behavioral and Experimental Economics Research on Terrorism,” *Behavioral Economics and Terrorism Conference*, sponsored by CREATE and Wharton Risk Management and Decision Process Center, USC, Los Angeles, CA, August 16-17, 2008
- von Winterfeldt, D., “Review of Research Needs and Topics,” *Behavioral Economics and Terrorism Conference*, sponsored by CREATE and Wharton Risk Management and Decision Process Center, USC, Los Angeles, CA, August 16-17, 2008
- von Winterfeldt, D., “Decision and Risk Analysis to Counter Terrorism,” *Third Annual Conference on Terrorism and Global Security*, RAND Corporation, Santa Monica, May 9, 2008
- von Winterfeldt, D. “Insights from CREATE Research to Counter Terrorism,” Aspen seminar, Los Angeles, April 2, 2008
- von Winterfeldt, D., “Experiences with Risk Analysis and Implications for Bioterrorism,” University Programs Summit (DHS), Washington, DC, March 20, 2008
- von Winterfeldt, D., Decision and Risk Analysis to Counter Terrorism, invited seminar, Wharton Risk Management Center, University of Pennsylvania, Philadelphia, PA, February 26, 2008
- von Winterfeldt, D., Decision and Risk Analysis to Counter Terrorism,” invited seminar, Science and Technology Directorate, DHS, Washington, DC, February 25, 2008
- von Winterfeldt, D., “Decision and Risk Analysis to Counter Terrorism.,” London School of Economics, Advisory Board to the Operational Research Department, February 18, 2008
- von Winterfeldt, D., “Risk and Economic Analysis of Terrorism Events,” Southern California Environmental Health Science Center, Los Angeles, CA, February 1, 2008
- von Winterfeldt, D., “Structuring Decision Problems for Analysis,” special interest group for Decision Analysis, Manchester, UK, December 12, 2007
- von Winterfeldt, D., “The DHS Centers of Excellence with CREATE as an Example,” *International Security and National Resilience Conference*, London, UK, December 3-5, 2007
- von Winterfeldt, D., “Insights from Applying Decision Analysis to Homeland Security Problems,” *Annual Conference of the Institute for Operations Research and Management Science*, Seattle, WA, November 5, 2007

Outreach:

- von Winterfeldt, D., “Risk and Economic Analysis of Terrorism,” presentation at the School of Policy, Planning and Development, for Board Members, USC, Los Angeles, CA, September 19, 2008
- von Winterfeldt, D., insights from CREATE research to help counter terrorism,” CREATE meeting with the Aspen Institute, USC, Los Angeles, CA, April 2, 2008
- von Winterfeldt, D., “Center for Risk and Economic Analysis of Terrorism Events,” Directors’ Meeting, *UP Summit*, Washington, DC, March 18, 2008
- von Winterfeldt, D., “Decision and Risk Analysis to Counter Terrorism,” Operational Research Group Advisory Board Meeting, London School of Economics, London, England, February 18, 2008
- von Winterfeldt, D., “Risk and Economic Analysis of Terrorism Events, Southern California Environmental Health Science Center, USC, Los Angeles, CA, February 1, 2008
- von Winterfeldt, D., “Center for Risk and Economic Analysis of Terrorism Events,” DHS Minority Serving Institutions Workshop, Fullerton, CA, November 29, 2007
- von Winterfeldt, D., “CREATE Overview - Accomplishments in 2007,” Government Advisory Council meeting, Los Angeles, CA, November 8, 2007
- von Winterfeldt, D., “Overview of CREATE,” DHS Scholars and Fellows Orientation Meeting, Washington, DC, October 6, 2007

5.3. Models, Databases, and Software Tools and Products

Date Delivered	Item	Agency Receiving Product	Agency POC	Commercialization Status
October 1, 2008	Dirichlet Elicitation Tool (DET)	BNBI, RMA	Michael	Delivered
October 1, 2008	Dirichlet Aggregation Tool (DET)	BNBI	Kuhlman, Gordy Garrett	Delivered

6. Education and Outreach Products

Education and Outreach Initiatives (Please detail below)	#
# of students supported (funded by CREATE)	4
# of students involved (funded by CREATE + any other programs)	4
# of students graduated	1
# of contacts with DHS, other Federal agencies, or State/Local (committees)	10
# of existing courses modified with new material	2
# of new courses developed	0
# of new certificate programs developed	0
# of new degree programs developed	0