

**Applications of Risk Analysis in Border Security**  
**Niyazi Onur Bakir, University of Southern California**  
**nbakir@usc.edu**

1.	Overview.....	1
2.	Research Accomplishments .....	2
2.1.	Security of Incoming Trucks to U.S. Southwestern Ports of Entry .....	2
2.2.	Risk Analysis of Advanced Spectroscopic Portals.....	3
2.3.	A Stochastic Game Model to Evaluate Overseas Cargo Security .....	4
2.4.	Port Security Resource Allocation Tool.....	5
2.5.	Evaluation of New Technology to Protect Airlines Against Plastic Explosives Threat.....	5
3.	Applied Relevance .....	6
3.1.	Risk-Based Resource Allocation.....	6
3.2.	Border security .....	6
4.	Collaborative Projects .....	7
5.	Research Products .....	7
5.1.	Publications and Reports .....	7
5.2.	Presentations .....	8
5.3.	Models, Databases, and Software Tools and Products .....	8
6.	Education and Outreach Products .....	8

**1. Overview**

I have been working on the border security case study in the past 3 years, focusing primarily on maritime and container security. This year, I expanded my research on several border security problems that were identified in previous years using traditional decision and risk analysis tools as well as stochastic games. The models developed this year covered different aspects of container security paradigm, extending from security of incoming trucks from Mexico to optimal resource allocation to reduce the risk of terrorism using overseas cargo. My goal has been to evaluate different alternatives comparatively to improve security at various nodes of container movement and provide insights into how we could do better with limited resources.

The first work has been on security of incoming trucks from Mexico. This study was largely developed in the previous calendar year. However, it was submitted to publication in *Decision Analysis* in this calendar year, and received positive response from referees. After major revisions, the study was finally accepted in this journal and will appear in this journal by December 2008. The main focus of this study is comparative evaluation of transportation security and inspection equipment to reduce the risk of radiological material transfer through southwestern borders. A risk analysis tool developed for this paper was also submitted to Risk Analysis Workbench for use by policy analysts.

Going in parallel with the trucks study was cost-benefit analysis of Advanced Spectroscopic Portals that DNDO is planning to deploy to ports of entry. There have been major criticisms against this program and DNDO contacted CREATE Director Prof. Detlof von Winterfeldt to conduct an independent study. We developed a decision tree model to understand how risk profile at U.S. ports behaves as a function critical parameters that largely impact the security situation at U.S. ports. The study is complete and will be submitted for publication in *Risk Analysis* after DHS review.

In addition to research using traditional risk and decision analysis tools, we also developed a stochastic game model in collaboration with Dr. Erim Kardes to understand how we should allocate resources in response to terrorist behavior. The main advantage of stochastic games is incorporation of terrorist behavior into the model while maintaining the practical validity of traditional risk analysis tools. This study also points out to the importance of early defense. This study has already been submitted to *Naval*

"This research was supported by the United States Department of Homeland Security through the Center for Risk and Economic Analysis of Terrorism Events (CREATE) under grant number 2007-ST-061-000001. However, any opinions, findings, and conclusions or recommendations in this document are those of the authors and do not necessarily reflect views of the United States Department of Homeland Security."

*Research Logistics* and a response from the journal editor and reviewers was still pending as of September 30, 2008.

In addition to research accomplishments, I was involved in two high profile projects in this calendar year. The first project is on resource allocation to improve security at Ports of Los Angeles and Long Beach. (POLA/LB). The goal is to develop a tactical tool that could help POLA/LB security directors make resource allocation decisions to counter daily terrorism threats. Mapping of the baseline risk profile of each terminal and pier is already complete. This is a multi-year project and in coordination with the other researchers in this study, I plan to finish the resource allocation prototype in the coming calendar year.

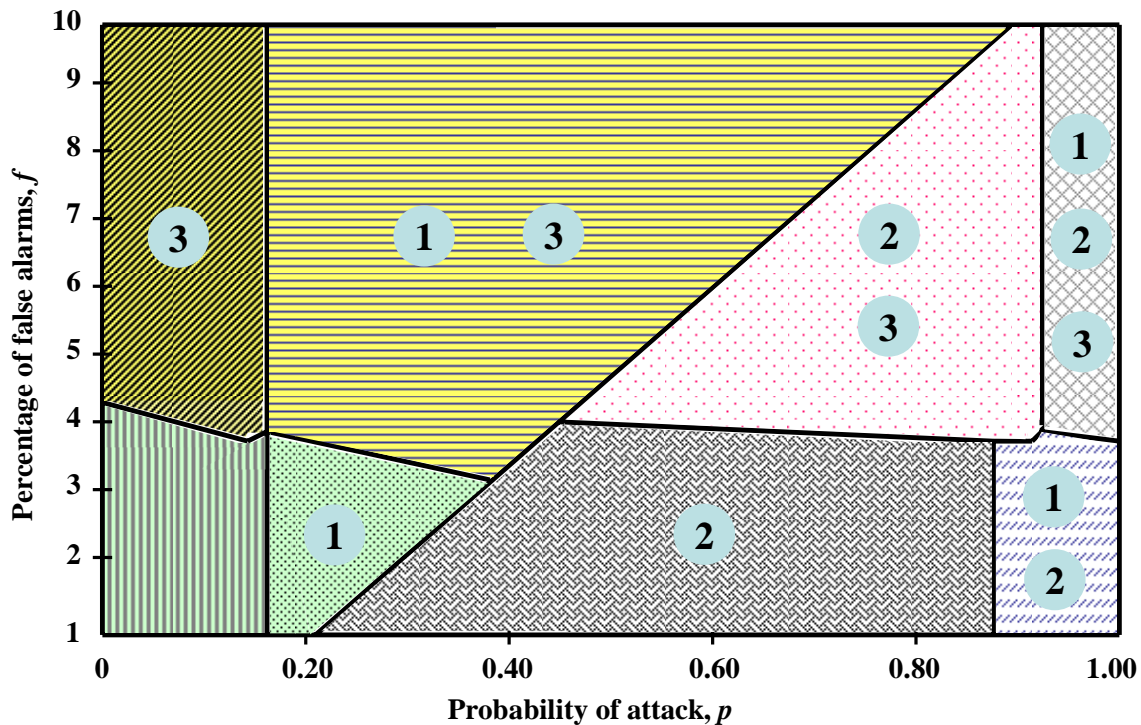
The second project is conducted in coordination with the LAX homeland security department and in collaboration with Technion Institute in Israel. The goal is to evaluate a new technology developed at Technion to improve plastic explosive detection capabilities at nation's airports. I have developed the decision tree model that we will use after feeding in the required information that will be collected from subject matter experts and experiments. The next stage in this project is the experiments to understand the practical validity of the tool. As of September 30, 2008, an experiment protocol was still in writing.

My research on container security has been using information from various reports on the security situation at various nodes of the supply chain and the ports themselves. Rather than evaluating a single security alternative, I focused on comparative evaluation of security alternatives. This line of research is expected to motivate more researchers in this domain to shift their focus on these problems and explore cost effectiveness of alternative defenses. The academic products of these studies have been received well in the community and are expected to get published in high quality journals.

## **2. Research Accomplishments**

### **2.1. Security of Incoming Trucks to U.S. Southwestern Ports of Entry**

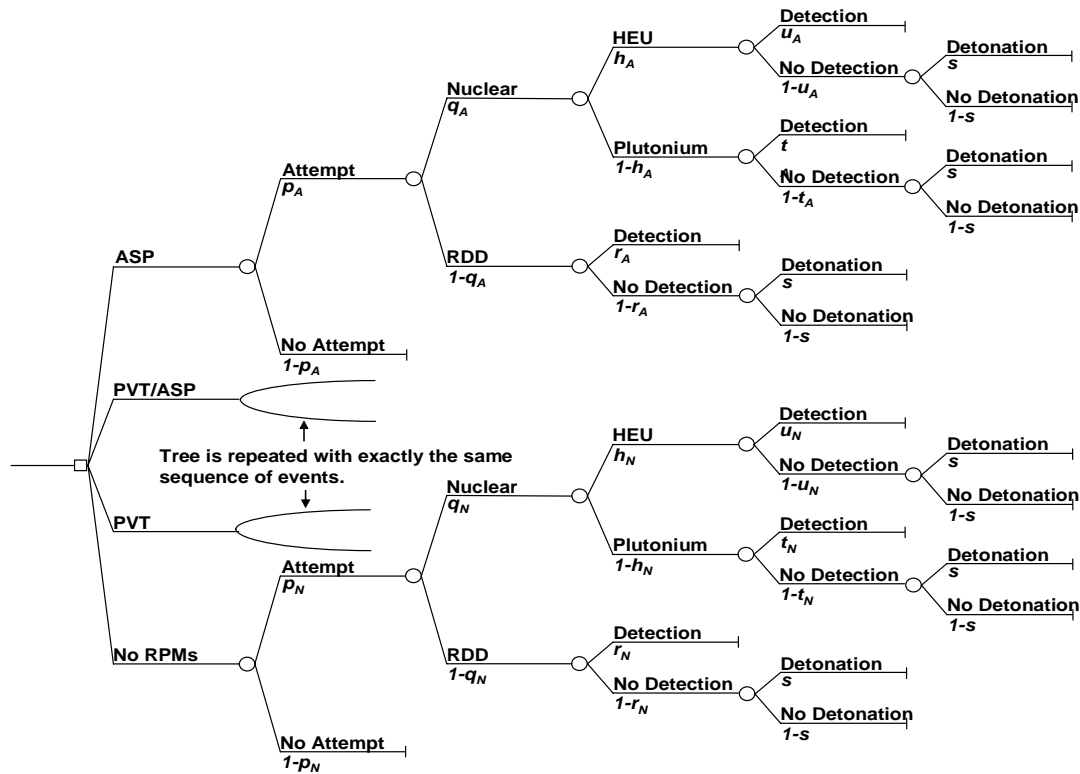
Building on earlier research, this study looks closely into the security of commercial truck operations at U.S. southwestern land ports of entry. A qualitative report that discusses the current practice of transporting goods via trucks and the security level associated with it was released in September 2006. This report concluded that certain measures have to be taken to reduce cargo transfer points, improve intermodal transportation security in Mexico and congestion at land ports of entry should be taken to help trucks move more efficiently and securely across the border. A follow-up quantitative analysis was conducted during 2007 and 2008 calendar years and a paper on this study was accepted in *Decision Analysis*. The results confirm findings in the earlier report in that transportation security technology should be a priority in countering terrorism risk whereas any security solution that could reduce false alarms at U.S. land ports of entry may be beneficial even if it does not offer extra detection capability.



- ① Improve transportation security
- ② Deploy plastic scintillators to Mexican ports of entry
- ③ Deploy Advanced Spectroscopic Portals to U.S. ports of entry

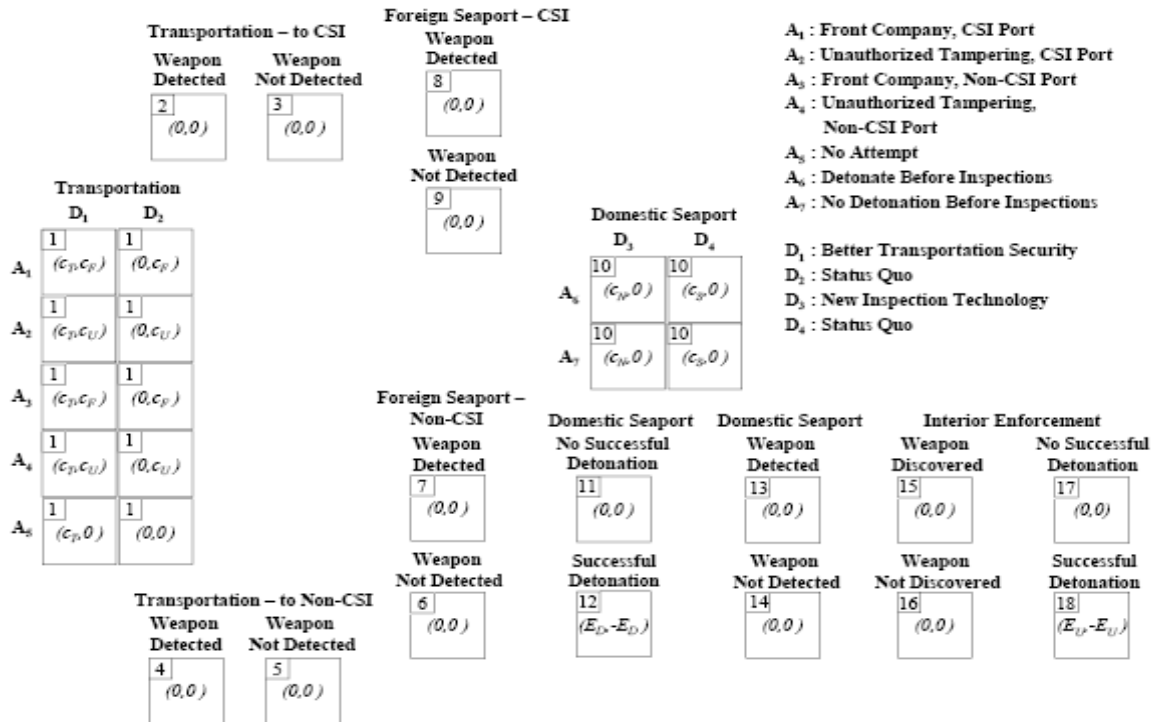
### 2.2. Risk Analysis of Advanced Spectroscopic Portals

This project was initiated per the request of Domestic Nuclear Detection Office (DNDO) to conduct an independent cost-benefit analysis of Advanced Spectroscopic Portals (ASPs). We analyzed the trade-off between the inspection performance and false alarms generated by the technology. We considered four alternative deployment strategies: 1) Exclusive deployment of ASPs replacing all the PVT currently deployed at U.S. ports of entry, 2) Sequential deployment of ASPs with PVT, 3) Exclusive deployment of PVT, 4) Stop deployment of new portal monitors and continue inspections with the current capacity. The baseline solution recommends sequential deployment that makes use of both technologies. However, this solution is found to be sensitive to the probability of attack attempt, the type of weapon shipped through ports of entry, the probability of successful detonation, detection probabilities and the extra deterrence that each alternative may provide. We also illustrate that the list of most significant parameters depends heavily on the dollar equivalent of overall consequences and the probability of attack attempt. For low probability and low consequence scenarios, false alarm related parameters are found to be significant as well. Our extensive exploratory analysis shows that for most parametric combinations either exclusive deployment of ASPs or sequential deployment of both technologies is optimal. ASPs become a more valuable alternative if the cost of false alarms and the probability of attempt are high. However, we also show that if ASPs fail to improve detection capability, then extra benefits they offer in reducing false alarms may not justify their mass deployment. This paper is currently reviewed by DHS and will be submitted to *Risk Analysis* once it passes their review.



### 2.3. A Stochastic Game Model to Evaluate Overseas Cargo Security

This project was initiated in collaboration with Dr. Erim Kardes to apply stochastic game methodology to container security problems and understand how security resource allocation decisions should be made in response to adversary behavior. The final product of this study is complete and has already been submitted for publication in *Naval Research Logistics*. A response from this journal's editorial board was still pending as of September 30, 2008. In this study, we consider two players; an attacker who plans to send a nuclear weapon, and a defender who considers two alternatives at two nodes of interdiction along the supply chain. The attacker can choose the path of the container, the method of intrusion and the target, whereas the defender chooses whether to improve transportation security and whether to improve inspections at domestic seaports. The base case results suggest that the attacker chooses to attack by sending the nuclear weapon under the disguise of a front company and through a foreign seaport that does not participate in the Container Security Initiative. The target of choice is likely to be a domestic seaport despite the higher economic toll of an urban area attack. The defender, on the other hand, chooses to improve transportation security, but not inspections at domestic seaports if the attacker plans to detonate the weapon before the authorities get a chance to act on it. We run sensitivity analyses to determine the most significant parameters of the model, and see how the baseline decisions change as a function of these significant parameters. The results in general recommend strong security measures along the entire supply chain rather than simply at the United States ports of entry. They also suggest that terrorists will probably execute the attack as soon as the weapon reaches United States shores to reduce the probability of interdiction. The results of this study are encouraging in that it gives further insights into optimal resource allocation incorporating the adaptive nature of the adversary. We plan to continue developing stochastic game models to explore resource allocation in container security under other scenarios and expand on our current model.



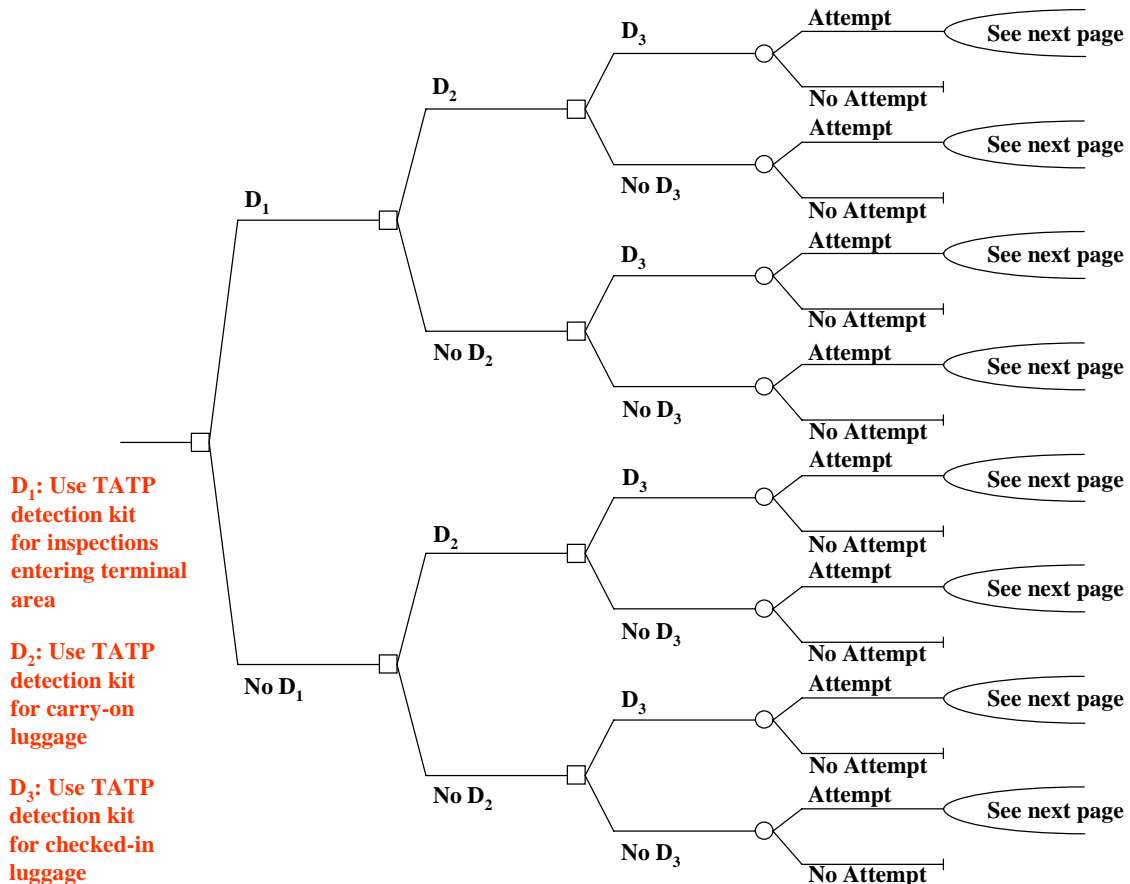
## 2.4. Port Security Resource Allocation Tool

This is collaborative study with other various researchers under CREATE umbrella to develop a tactical tool that helps POLA/LB security officials make daily resource allocation decisions. The collaborators are Dr. Isaac Maya, Dr. Mike Orosz, Prof. Petros Ioannu, Dr. Henry Willis and Dr. Don Kleinmutz. This project has several pieces. The most major piece that I am involved with seeks to define the baseline risk profile at the port complex, identify countermeasures to improve the risk profile and quantify their positive impact on the baseline risk profile. To this end, a baseline risk profile was created with the help of two DHS scholars over the summer of 2008 under my direction using open internet resources and after several visits to the port. To reduce the complexity in mathematical calculations, a similarity matrix has been developed as well. The next stage is to develop models to quantify the risk reducing impact of countermeasure alternatives and to understand the microeconomic impacts of terminal and pier closures. After this stage is completed, we will utilize the resource allocation expertise that our team has, and combine it with the software side to finalize the tool. The software is also under development in parallel to the developments in the risk analysis side as well.

## 2.5. Evaluation of New Technology to Protect Airliners Against Plastic Explosives Threat

This project is currently underway in collaboration with Technion Institute in Israel and homeland security department at LAX. CREATE brings in the risk analysis expertise in this project. A risk analysis model was developed in this calendar year. The model incorporates various security layers at LAX and the checkpoints. The goal is to explore the most effective way to use this new plastic explosive detection technology. We are currently in the process of populating the model with relevant

probability and consequence information. As of September 30, 2008, a protocol for experiments with the tool was still in writing. This protocol is based on meetings with LAX and Transportation Security Administration (TSA) personnel. We plan to finalize the project by April 2009. There is an academic component of this project as well. I believe findings of this study could be published as an academic paper in 2009.



### 3. Applied Relevance

#### 3.1. Risk-Based Resource Allocation

My research has a lot of relevance for risk based resource allocation in container security. Models populated through extensive literature review and data collection are used to evaluate various alternatives to improve security comparatively. I believe the results will provide insights to policy and risk analysts. The focus on the projects that are described above are generally on securing supply chains and ports and various technologies and policies should be implemented to optimize allocation of limited resources.

#### 3.2. Border security

My research is on border security and most of the work described above is relevant to land border and maritime security. The study on the security of commercial trucks along the southwestern borders has relevance to land border security whereas the study on evaluation of ASPs is relevant to maritime

security. The stochastic game study focuses exclusively on maritime security. All these projects are on containerized cargo security. On the applied project side, the port risk based resource allocation tool addresses maritime security concerns at the nation’s biggest port complex. The focus is on port infrastructure security rather than cargo security. The plastic explosives study at LAX has relevance to air borders. If the tool evaluated in this study is found to be cost effective, then it is expected to be used in other airports in U.S. and elsewhere. In this regard, this project is expected to have a significant air border security impact.

#### 4. Collaborative Projects

The project on port security is conducted in collaboration with the POLA/LB homeland security offices. We do not seek funding from them. Our goal is to help a local stakeholder make a critical decision in a risk informed manner. With their input, we are developing model that lays down the current risk profile at the port complex and the impact of selected countermeasures in reducing this risk. This model will be armed with a risk allocation module that will help the port authorities improve daily security decisions. We also collaborate with ISI in this project, and their help is sought on the software side.

Under separate funding from DHS, we are also collaborating with the LAX homeland security office and Technion Institute in Israel to evaluate a new technology that detects plastic explosives. My role is to develop a risk analysis model. After the experiments in Los Angeles and Heathrow Airports are completed, we will obtain the final results as to whether the use of new technology is justified.

#### 5. Research Products

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

##### 5.1. Publications and Reports

Publications	Ref	Not Ref
1. Bakir, N. O., Kardes, E., “A Stochastic Game Model on Overseas Cargo Container Security,” <i>Naval Research Logistics</i> , under revision	x	
2. Bakir, N. O., von Winterfeldt, D., “Is Better Nuclear Weapon Detection Capability Justified?” working paper, 2008		x
3. Bakir, N. O., “A <i>Decision Tree Model</i> for Evaluating Countermeasures to Secure Cargo at Southwestern Ports of Entry,” under review, <i>Decision Analysis</i> , 2008	x	
4. Savachkin, A., Bakir, N. O., Uribe A., “An Optimal Countermeasure Policy to Mitigate Random Capacity Disruptions in a Production System,” <i>International Journal of Agile Systems and Manufacturing</i> , Vol 3, Nos.1-2, 4-17, 2008	x	

## 5.2. Presentations

### Conferences

- Bakir, N., Savachkin, A., Uribe, A., “Capacity Disruptions and Associated Countermeasures,” *POMS Conference*, San Diego, CA, 2008
- Bakir, N., “Cargo Security at Land Ports of Entry,” *POMS Conference 2008*, San Diego, CA
- Bakir, N., Kardes, E., “A Stochastic Game Model on Overseas Cargo Container Security,” *INFORMS Annual Meeting*, Washington D.C., Oct 12, 2008
- Bakir, N., “Securing Cargo at Southwestern Ports of Entry,” *INFORMS 2007*, Seattle, WA

## 5.3. Models, Databases, and Software Tools and Products

A risk analysis tool to evaluate the security of commercial trucks along the southwestern borders has been completed and delivered to RAW during this calendar year. Another tool for the cost-benefit analysis of Advanced Spectroscopic Portals that was developed for the DNDO study will be delivered as soon as the paper passes the DHS review and is ready to be submitted as a journal publication. Upgrades on these tools may be made as circumstances warrant. In addition, a software tool to analyze the daily security threats at POLA/LB is currently under development as a part of the port security project. Major developments on this tool are expected during the next calendar year.

## 6. Education and Outreach Products

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

Two students were supervised during this calendar year. Both were DHS summer visitors working on the port security project. They helped me develop the current risk profile at the port complex. No outreach activities were conducted during this period.