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1. EXECUTIVE SUMMARY

In June, 2003, the Department of Homeland Security (DHS) issued a broad agency announcement (BAA) requesting white papers for the first university center of excellence to be funded by the DHS. This center was to focus on risk and economic analysis of terrorism. Seventy-two universities responded to the announcement, including USC and its core partners at the University of Wisconsin, New York University, and Structured Decisions Corporation. Twelve of the applicants were invited to submit detailed proposals, and four applicants were visited in August, 2003 by a team of academics and DHS representatives. In November, 2003, USC was selected to lead the first university based Center of Excellence, which was called the Center for Risk and Economic Analysis of Terrorism Events (CREATE).

CREATE began operation in March, 2005, as soon as funding became available. In addition to the three core partners, CREATE involved several other institutions, either directly subcontracted through USC or through its core partners. A list of participating institutions is shown in Table 1.

CREATE’s mission is to develop advanced models and tools to evaluate the risks, costs and consequences of terrorism and to guide economically viable investment to counter terrorism. CREATE accomplishes its mission through an integrated program of research, education and outreach, spanning the disciplines of engineering, social science, and information science. CREATE develops models, methodologies and software, and tests these tools in case studies, representing critical investment and policy decisions.

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<td>University of Illinois at Urbana-Champaign</td>
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<td>University of Wisconsin Madison</td>
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CREATE summarized its activities in two previous reports, an annual report covering the first year and a semiannual report covering the period from April to September, 2005. The current report provides a comprehensive description of CREATE’s activities during its first two years. Appendix A provides an accounting of all expenditures and budgets, by projects and cost categories. Appendices B and C provide one-page summaries for all projects conducted in years one and two.
The followings six sections of this summary follow the six evaluation criteria for the renewal review. In addition, we include a section the vision and mission for the renewal of CREATE.

1.1 Research Accomplishments

Our center’s research activities cover three modeling and analysis areas (see Figure 1):

- Risk Assessment
- Economic Assessment
- Risk Management

Risk assessment includes an assessment of the threats, vulnerabilities, and consequences of terrorism attacks. Economic assessment includes the assessment of direct consequences, the assessment of indirect economic impacts, and the evaluation of measures to counter terrorism through cost-benefit and decision analysis. Within each modeling area CREATE researchers conduct a mix of fundamental and applied research. For example, in the risk assessment area, we have applied state-of-the art probabilistic risk analyses models and also developed advanced game theoretic models to terrorism problems. In economic impact modeling we applied relatively standard input-output economic models, but we also explored the use of advanced computable generalized equilibrium and behavioral models. In risk management our initial applied focus was on emergency response and recovery models, but we have recently shifted to examine advanced models for prevention and protection of terrorist attacks.

Figure 1. CREATE Research Framework

To provide cohesiveness and realism to our modeling activities, we exercise our models in case studies of specific threats. During the first year, we analyzed the threat of surface to air missile attacks against commercial airlines in the US, dirty bomb attack on US harbors, and
sustained attacks on regional electricity systems. In the second year we studied bioterrorism, border security, and risk based allocation of grants to cities and states. All project teams are encouraged to pursue some aspect of the case studies, while they are also encouraged to pursue fundamental research. Of the 24 current projects, 14 are directly linked to the case studies.

CREATE has engaged 34 tenure track faculty members at USC and its partnering institutions. Faculty members typically receive support for two months for working on CREATE projects. Key faculty strengths are in risk analysis (Bier, Bank, Ross), decision analysis (John, Kleinmuntz, von Winterfeldt), economic impact analysis (Gordon, Moore, Richardson, Rose), economic benefits analysis (Lave, Smith), behavioral economics (Bostic, Redfearn), computer science (Tambe, McLeod), and operations research (Dessouky, Hall, Larson, Ordonez, Tien). The team includes one member of the National Academy of Sciences (Smith) and one member of the National Academy of Engineering (Tien). In addition to the tenure-track faculty, CREATE has also involved 20 other Ph.D. level researchers, including four post-doctoral scholars.

The main intermediate research output of this team consists of publications, scientific presentations, and of CREATE-organized symposia. During the first two years, CREATE researchers produced 132 publications and gave 188 presentations. The 132 publications include refereed articles, non-refereed articles, book and proceedings chapters, and reports. All of them are either published, in print, accepted or under review. The distribution is as follows:

- Six edited books
- One edited journal
- 44 peer reviewed articles
- 56 book chapters or conference proceedings
- 25 CREATE reports

Other research products include models for risk and economic analysis and an integrated modeling environment, the Risk Analysts’ Workbench (RAW). The risk analysis models include software for specific risk applications, e.g., a decision analysis model to evaluate MANPADS countermeasures. A new economic impact model was developed, called NIEMO for National Interstate Economic Model that is used to estimate the economic impacts of a terrorism event and disaggregates the impacts spatially by the states in the US. RAW is the most ambitious software product, which is at one level a repository of all of CREATE’s models and tools and at another level a tool in itself that will enable terrorism researchers across the country to access data bases, risk and economic models, and applications of these models.

CREATE researchers are very highly cited. For example, ISI Web of Science citation index count data indicates that several CREATE researchers have achieved lifetime citation counts above 1000, including Peter Gordon, Michael Greenberg, Richard Larson, Harry Richardson, Todd Sandler, Jeffrey Simonoff, Kerry Smith, Milind Tambe, and Detlof von Winterfeldt. Many more CREATE researchers have achieved citation counts in the high hundreds. Our research results are already making an impact by organizing several symposia and conferences at CREATE as well as at other national venues. For example, CREATE
organized three scientific symposia on risk and economic analysis and co-sponsored several others.

CREATE researchers have also provided testimony to or were members of several national committees related to homeland security. For example, von Winterfeldt testified before the House Committee on Homeland Security’s Subcommittee on Information Sharing and Terrorism Risk Analysis. He also was a member of the National Academies’ Board on Mathematical Sciences and their Applications and of the Committee on Defense Modeling, Simulation, and Analysis. Vicki Bier and Rae Zimmerman were on the EPA’s Homeland Security Advisory Committee of its Science Advisory Board. Peter Gordon, Bob Neches, Adam Rose, and Rae Zimmerman also participated in committees of the National Academies. In total, CREATE faculty were represented on 18 major committees.

Some general insights of our first two years of risk assessment research are:

- **Risk analysis of terrorism is more difficult than other types of risk analyses**
  
  o Probabilities of a specific threat are especially hard to assess, because of the lack of data and the dependence of threat probabilities on the motivation and capabilities of terrorists
  
  o Probabilities of a successful attack, given an attempt are somewhat easier to assess, especially when conceiving a terrorist attack as a project that has risks of failure
  
  o Probability distributions over the consequences of a successful terrorist attack is the easiest part of terrorism risk analysis and many tools for consequence assessment have been developed in other disaster context

- **Adversarial risks are different from natural or engineered risks**
  
  o Adversaries seek vulnerabilities and high consequences
  
  o Probabilities of threats and attacks shift with our action
  
  o Some risk assessment tasks are easier. Using terrorist motivation and capabilities allows us to screen and significantly reduce attack scenarios
  
  o While it is hard to assess absolute probabilities, relative probabilities can often be assessed

- **A terrorist attack is a complex multistage project**
  
  o A large terrorist attack is not unlike any other large projects, which required planning, resources, logistics, and execution
  
  o Like any large project, terrorist attacks have vulnerabilities and provide multiple intervention opportunities
  
  o Upstream interventions are the early stages of an attack plan or execution are most cost-effective in disrupting terrorist attacks

- **Focus on risk management helps**
  
  o Not all countermeasures are cost-effective
  
  o Conclusions are often robust with respect to “soft” inputs
Resilient response and behavioral adjustments to terrorism events often reduce the economic impacts substantially.

1.2 Applied Relevance

While the CREATE leadership is mindful that the DHS university centers add the most value by conducting long term fundamental research that advances the knowledge base and the intellectual capacity of our nation to counter terrorism, we also promote application of the research to make a difference in medium term policy debates. To accomplish this, CREATE has used an approach that encourages the application of fundamental research ideas to specific problems relevant to the DHS and the Nation. CREATE teams accomplish this by conducting three case studies each year. Case studies are presented as current or future terrorism issues or problems faced by the DHS or other agencies.

Case studies are selected in close interaction with CREATE’s scientific advisory committee (SAC), which includes DHS staff ex officio. Criteria for case selections are the importance of the issue to the DHS, the likelihood of scientific advances in the context of the case study, and the expertise of the CREATE team relevant to the case study. The CREATE team usually proposes 5-6 candidate case studies and selects three based on guidance of the SAC.

In year one, we completed the MANPADS (Man Portable Air Defense Systems) case study, in which we evaluated the cost-effectiveness of surface-to-air missile attack defense systems against commercial airplanes, a study of a dirty bomb attack on the LA and Long Beach Harbors, and a study of a sustained attack on a regional electricity system. Of these the studies, the MANPADS study was most closely linked to clients at the DHS and had the most direct impact. The client was the congressionally funded Countermeasure MANPADS Office, which has a $100 million dollar program to evaluate the technical and economic feasibility of MANPADS countermeasures. CREATE was not directly contracted by the Countermeasures MANPADS Office, but met with its staff three times and eventually delivered several papers and two software products to assist them in evaluating the cost-effectiveness of MANPADS countermeasures. The CREATE software tools and economic impact analyses were helpful in establishing the cost-effectiveness of these countermeasures.

The other two first year case studies and results were also relevant for decisions in homeland security, though they were less closely linked to specific needs or clients at the DHS. The dirty bomb study investigated 36 scenarios of an attack on the Los Angeles/Long Beach harbors with radiological dispersal devices ranging from small to very large. The analysis concluded that there would be relatively minor health effects, but large economic impacts due to the shut down of the harbors, evacuations and decontamination efforts. The analysis also suggested the need to prepare the public for this type of an attack and to be proactive in setting radiological decontaminations standards that are less stringent than those promulgated by the Environmental Protection Agency for normal radiation exposure. The electricity case study also indicated large economic costs of a sustained blackout and led to proposals for improved security systems as well as redundancies in the electrical system that would make it more reliable and secure.
The three case studies in year two are still underway. A lesson learned from year one was that it is useful to connect with clients in the DHS early in the development of the case study. As a result, we engaged specific clients for each of the three studies. In bioterrorism, we are working closely with the National Biodefense Analysis and Countermeasures Center (NBACC). CREATE teams are conducting several analyses, including a new approach to assessing terrorist preferences for biological agents, a project risk analysis of an anthrax attack, and economic analyses of the consequences of bioterrorism.

In the area of border security, we are working closely with the Office of Customs and Border Protection (CBP) and the Immigration and Customs Enforcement Divisions (ICE) of the DHS. On the threat side, CREATE is collaborating in a major tabletop exercise of a terrorist attack on the borders. On a systems level, we are studying the vulnerabilities of the border system as a whole and examining the allocation of investments. On a sub-systems level, we are teaming with the Los Angeles County’s Sheriffs Department to study the cost-effectiveness of installing radiological monitoring devices at the Marina Del Rey, the largest pleasure boat harbor in the world.

In the area of risk-based resource allocation, CREATE has teamed with the California Office of Homeland Security to conduct a pilot study for evaluating alternative investments in a dozen infrastructure assets in California. This effort is also supported by the RAND Corporation and by AIR International. This will help DHS in its allocation of resources to states and urban areas, which has been a point of contention for several years. The Risk Management Division of the DHS Office of Infrastructure Protection recently made many improvements toward the goal of a “risk-based” allocation of resources. These improvements basically use some risk formula to guide investments from the top down. We have taken a different approach by analyzing risks and cost-effective risk reduction from the bottom up.

In addition to these case studies, we have also conducted specific economic impact analyses that were relevant to the DHS, including

- Shutting down the aviation system in the US
- Shutting down selected harbors in the US
- Attacks on major tourist attractions
- Attacks on regional electricity systems
- Foot and Mouth Disease

Furthermore, we have or are collaborating with several other DHS, regional, and local agencies on a number of issues, including:

- Review of bioterrorism risk analyses conducted by the DHS
- Participation in the Katrina decision tree analysis task force
- Development of material for risk analysis short courses
- Study of electricity reliability and security for the California Energy Commission
- Study of the LA County plan to disseminate biological countermeasures
1.3 Management

In its first year of operation, CREATE was managed by Randolph Hall (Principal Investigator and co-Director) and Detlof von Winterfeldt (co-Director). Dr. Hall was responsible for the general management of the center, educational programs and the engineering-focused research programs. Dr. von Winterfeldt was responsible for overseeing research in the risk and economic analysis areas. Both investigators had past experience with the management of large interdisciplinary centers. Dr. Hall managed the Metropolitan Transportation Research Center at the Viterbi School of Engineering (VSOE) and Dr. von Winterfeldt managed the Institute for Civic Enterprise at the School of Policy, Planning, and Development (SPPD). They also had significant administrative experiences with Dr. Hall being Senior Associate Dean for Research at VSOE and Dr. von Winterfeldt being Deputy Dean at SPPD.

On July 1, 2005 Dr. Hall was appointed Vice-Provost for Research Advancement of the University of Southern California and Dr. von Winterfeldt assumed the position of Principal Investigator and Director of CREATE. At the same time he resigned from his position as Deputy Dean to focus his attention on CREATE. In July, 2005 Dr. Isaac Maya was hired as Director of Research to oversee the management of all CREATE research projects.

The center is supported by three full-time staff, Sabrina Feeley (Business Manager), Kelly Gribben (Public Communications Manager) and Dr. Harry Bowman (GIS programmer). In addition, CREATE hired four post doctoral researchers to conduct analyses in key areas. Dr. Terrence O’Sullivan (Ph.D. International Relations, USC) works in the area of risk assessment, and has specialized in aviation and biological threats. Dr. Onur Bakir (Ph.D. Industrial Engineering, Texas A&M) also works in risk assessment, and has specialized in border security. Dr. Luca Quadrifoglio (Ph.D. Operations Research, USC) joined the center as a specialist in optimization modeling and analysis of grant allocation systems. Alexia Brunet (Visiting Professor, Northwestern University) was a post doctoral researcher during the summer of 2005, before accepting her current position at Northwestern. She studied risk-based allocations of DHS grants to states and urban areas.

To aid in the management of the projects and case studies, we recently implemented an additional structure of thematic supervision and coordination. To accomplish this, Dr. Adam Rose assumed the role of coordinator of all the economics activities and projects. Dr. Vicki Bier agreed to coordinate all the risk analysis projects. Dr. Isaac Maya is coordinating the risk management activities.

With the arrival of Sabrina Feeley as business manager and Dr. Isaac Maya as research director, we have created several new financial and project management systems. On the financial side, we have well-defined quarterly financial reports by projects and by general expenditure categories. On the project management side, we have an improved system of quarterly project progress reports and, with Dr. Maya’s supervision, a process of continuous hands-on monitoring of each of our projects and subcontracts.

The center management operates under the guidance of the Scientific and Government Advisory Committees (SAC). The SAC consists of scientists working in homeland security
related areas of research. It includes Dr. Ralph Keeney (Chairman, Duke University), Dr. John Cummings (Sandia and DHS), Dr. Howard Kunreuther (University of Pennsylvania) and Dr. Jack Riley (RAND) as original members, with Dr. Mel Bernstein (DHS) as ex officio member. Four members were added in 2005: Dr. Sherry Borener (NASA), Dr. Robin Keller (University of California at Irvine), and Dr. Matthew Clark (DHS, ex officio). The SAC provides technical direction to the center and reviews the center’s products and plans.

The Government Advisory Committee (GAC) represents government and non-profit organizations (such as industry associations) and provides guidance on areas where research products are needed. The GAC includes sub-groups in the Western, Midwest and New York regions. CREATE is also working on the establishment of an Industry Advisory Committee (IAC). Over the two years, we had many contacts with industry representatives interested in homeland security and we initiated a formal contact with an industry breakfast meeting in November of 2004. More recently, we announced the creation of a formal Industry Advisory Board with modest membership fees.

USC is very supportive of CREATE. The Provost and the Deans of the Viterbi School of Engineering (VSOE) and of the School of Policy Planning and Development (SPPD) have made significant commitments to CREATE. In terms of space commitments, CREATE occupies approximately 2,685 square feet in both VSOE and SPPD. CREATE’s headquarters are in VSOE’s Ronald Tutor Hall, which was built with the intent to serve interdisciplinary research. Both VSOE and SPPD support CREATE with operational funds, scholarships for eligible research assistants, and a generous tuition remission match (CREATE pays 25% of tuition and the schools pay 75% for each CREATE research assistant).

1.4 Education

Even though the original broad agency announcement for this center did not mention education, CREATE’s proposing team felt strongly that a mix of research, education, and outreach was needed to make the center successful. This was based on the previous experience of Dr. Hall in developing the METRANS center and of Dr. von Winterfeldt in developing the Institute for Civic Enterprise at USC. Since universities are in the business of educating students, the proposal emphasized the need for integrating an educational mission with the research mission of the new center to align the needs of the DHS, the center, and our incoming students.

While we were ahead of the times when we implemented our educational mission, we are now experiencing an increased emphasis on education in the University Programs of the DHS. More recent BAAs have stressed the educational mission and, in particular, asked for involvement in minority serving institutions. Centers that were funded more recently were guided to invest increasing resources in education than CREATE had originally envisioned. As a result, CREATE has further increased its efforts in education and has made significant progress.
Most importantly, we believe that the main educational benefit from the university centers comes from training the next generation of experts in a broad range of homeland security issues. Local, regional, state, and federal agencies have an increasing need for expertise in this area. CREATE’s initial focus was on the higher education levels – Ph.D.s who could assume senior positions in academia, government, and industry. We were highly successful – recruiting more than 35 Ph.D. students into our projects. Most of these Ph.D. students are or will be writing Ph.D. theses on terrorism and homeland security. In addition to the Ph.D. students, CREATE supports about 30 masters and 7 undergraduate students, bringing the total of CREATE research assistants to nearly 75 nation-wide in a variety of disciplines.

We also created new masters and certificate programs in System Safety and Security, which were officially launched at USC in the Fall of 2005. Part of this program included new courses in risk analysis and terrorism policy. The new courses taught in this program are well attended, but the program still has few enrolled students. This is partly due to some restrictive entry requirements, and partly due to the lack of an aggressive recruitment program. We are now much more active in recruitment and we are reviewing the entry requirements.

Under CREATE support and guidance, three graduate new level courses have been developed and another twelve courses have been modified to incorporate CREATE research and/or homeland security issues.

USC has a first-rate aviation safety program that has operated for more than fifty years with more than 21,000 aviation professionals having completed its courses to date. This program is a close partner of CREATE and, as part of the collaboration with CREATE, it was renamed the “Aviation Safety and Security Program” in 2005 and a new course in aviation security was developed in 2005. We are working on a second course in system safety.

We hosted four DHS scholars in the summer of 2005. These students were exceptional and all of them produced very interesting and insightful research papers which are available on our web site. This summer we are scheduled to host five DHS scholars, four at USC and one at NYU.

CREATE is committed to diversity and upholds it as a guiding principle in all of its programs. CREATE has made several efforts in diversity-specific programs as well. First, we supported the DHS minority program in 2005 by hosting three faculty members and four students from minority serving institutions. One of the teams was very successful and we extended an invitation for the team to return in 2006 with funding from CREATE. This will result in the establishment of an official center partnership with Elizabeth City State University, an HBCU in North Carolina. We have reviewed six proposals for the 2006 summer, and plan to accept four minority faculty-student teams this year, three at USC and one at NYU. We also established a relationship with the Thomas Rivera Policy Institute (TRPI) at USC, a nationally recognized Hispanic policy institute. With joint funding from TRPI and CREATE, we have studied issues related to the implementation of NAFTA agreements at the Mexican border. Third, we actively searched for faculty members at Historically Black Colleges and Universities and at Hispanic Serving Universities to find faculty members that match the research interests at CREATE. This search is still ongoing. As dual outreach-education efforts, CREATE also
contribute to the educational programs of local minority-serving high schools, holding lectures
on issues of security and hosting interns on a semester basis.

CREATE conducts internal seminars and training sessions, including a six-hour lecture
series by Dr. Adam Rose on economic impact assessment models, held in the fall of 2005. We
are now developing a similar series of lectures on decision and risk analysis in the form in a short
(six hours) and long (three days with exercises) form. These sessions will be webcast and made
available to other University Programs centers and to interested parties at the DHS. To
encourage intellectual exchange and broader reach, CREATE also hosts interns and faculty
members from visiting institutions for periods ranging from one week to 3 months.

CREATE has also been dedicated to the development of innovative educational vehicles
in homeland security related topics. Using gaming technology, the center is currently engaged in
a project with the educationally focused GamePipe Lab at USC to develop a serious training
game for emergency responders. As another innovation, our degree and certificate programs and
many of our classes are available on-line through USC’s Distance Education Network. In
addition, CREATE will take advantage of USC’s web-based technologies for web casting
seminars. These educational innovations will ensure broader access and enable us to adapt to the
culture of today’s students.

1.5 Outreach, Communication, and Transitioning

CREATE has been very active in its outreach efforts, sponsoring three major research
symposia and six conferences, attended by more than 1,000 people and including speakers from
over 60 organizations, on the following topics:

- Economic Costs and Consequences of a Terrorist Attack (August, 2004)
- Reducing the Risks and Consequences of Terrorism (November, 2004)
- Terrorism Risk Analysis (January, 2005)
- Maritime Cargo Security (March, 2005)
- National Symposium on Terrorism Risk Insurance (June, 2005)
- Economic Impacts and Costs of a Terrorism (August, 2004)
- US/UK Cooperation and Partnerships for Homeland Security Solutions (September, 2006)
- National Symposium on Terrorism Risk Insurance (October, 2005)
- CIA Regional Intelligence Conference (February 2006)

CREATE’s other outreach efforts included hosting visitors from more than 50
organizations, inviting more than 60 organizations to speak at CREATE sponsored events, giving
188 external presentations about our center and our research, initiating more than 40
collaboration meetings with industry, continuing a successful media relations program,
developing a center logo and branding, and expanding and enhancing the center’s website.

We developed a website that is continuously updated and receives more than 200 hits per
day, a short brochure describing CREATE that was updated recently, and an electronic
newsletter which is sent to approximately 1,000 contacts in our database. In 2005, we developed
an official CREATE logo and identity program. We receive approximately 10 media inquiries
per month, and maintain contact with the media on a regular basis. As of March, 2006 we had over 100 media interviews.

We have developed many contacts in the operational units of the DHS, partly by seeking out clients and users of our case study methodologies and results, and partly by DHS staff seeking our advice. Secretary Chertoff’s emphasis on risk based decision making has created substantial interest in collaborations with CREATE. Examples of clients of our case studies are the Countermeasure MANPADS office, the Office for Border Control and Protection, the Immigration and Customs Enforcement Office, the Office of Infrastructure Protection, and the National Biodefense Analysis and Countermeasures Center. All of these contacts have evolved in collaborative projects that are jointly supported by the DHS and by CREATE.

In addition to working closely with clients at the DHS, we have clients in regional and local agencies. These include the California Energy Commission, the California Department of Health and Human Services, the California Office of Homeland Security, the Los Angeles Mayor’s Office, the Los Angeles County’s Sheriff’s Department, the Los Angeles County Health Department and the Los Angeles Fire Department. Similar collaborations exist at UW-M and at NYU. In addition, we communicate with the local and regional homeland security, law enforcement, and emergency response community through our regional government advisory committees. We communicate with industry through frequent one-on-one meetings. We have had more than 100 industry contacts since the inception of CREATE and about 40 collaboration meetings with industry partners. Some of these contacts have resulted in joint proposals.

Due to our early emphasis in the applied development of models and software tools, we have already made our tools available to some clients. Perhaps the best example are the software tools developed to assess the cost-effectiveness of MANPADS countermeasures, which were demonstrated in a prototype form to the Countermeasures MANPADS office in the summer of 2005 and made available with reports and documentation in November of 2005. Other software tools, including those developed for the dirty bomb case study and for emergency response were demonstrated to several emergency planning agencies, police and fire department in the US.

We plan to make use the Risk Analysts’ Workbench as CREATE’s major electronic portal for disseminating software tools, exercised models, papers describing the models and their results, and data bases. Currently, RAW contains five decision and risk analysis software tools, three exercised models, and two data bases on terrorism. Access is provided through a secure server housed at USC’s Information Sciences Institute.

1.6 Integration

Integration across projects within the center is achieved through the matrix structure of CREATE’s research. Within each research area, research projects are coordinated to allow investigator flexibility to innovative basic research while minimizing duplication of effort. For example in the risk assessment area, the game-theoretic research projects of Bier and Hall explore complementary approaches to analyzing the indeterminate probabilities of terrorist actions based on their observations of site defenses. In the economic assessment area, the input-
output models of Gordon, Richardson and Moore are complemented with the computable generalized equilibrium model of Rose.

The case studies are, by their very nature, interdisciplinary. For example, to develop the dirty bomb model and analysis required the expertise of risk analysts, decision analysts, counterintelligence experts, blast and plume modelers, radiological health effects experts, decontamination experts, behavioral researchers with knowledge about evacuation behavior, and economists. In the resource allocation case study, CREATE is integrating approaches applicable at the site and building level (Bier and Bank), infrastructure level (Zimmerman, et al.), city level (Bier), and state level (Kleinmuntz and Quadrifoglio). Not all the expertise required for a case study is obtained within CREATE. CREATE has integrated outside expertise, such as the national laboratories, which have been extremely helpful in providing models and information. CREATE has also occasionally asked for special outside expertise, for example, in radiological detection devices and in counterterrorism. One of the strengths of the center approach is the ability to create mixes of expertise to work on a common problem efficiently.

Many of our projects integrate products from multiple institutions within CREATE. For example, NYU, UW-M, USC, Cornell, and CMU faculty all worked on the electricity case study. The resource allocation case study is integrating input from UW-M, NYU, and USC. Two ongoing projects involve CREATE and other DHS centers of excellence. UW-M and USC researchers work with the Foreign Animal and Zoonotic Disease Center on the risk analysis aspects of foot and mouth disease. UW-M and the National Center for Food Protection and Defense collaborate on risk analysis in the food supply chain. We also recently invited START to participate in our border security case study tabletop exercise with the DHS Office of Customs and Border Protection.

The Integrated Network of Centers (INC) is our main vehicle for inter-center collaborations. The seven center directors meet regularly by phone and bi-annually in person to discuss joint activities, gaps in research, education needs, etc. The most recent INC meeting was hosted by CREATE. At the last INC meeting in January of 2006, several themes for cross-center collaborations were identified and leads were assigned to these themes. CREATE is leading two collaborative efforts, one on risk perceptions of terrorism and one on economic impacts, and has representation in the other five, with three representatives from USC, one from UW-M, and one from Strategic Decisions Corporation.

CREATE participates in the DHS Science and Technology Action Team (STAT) activity. This activity integrates participants across all the DHS national laboratories and Centers of Excellence. CREATE has closely collaborated with the other COEs in identifying the special needs of COEs relative to national laboratories in compiling our responses to DHS requests for information. The result has been the development of a customized template that accommodates the research and developmental nature of university projects while still suitable for DHS’ needs in emergency response.

CREATE also integrates its research with industry input. We routinely meet with Boeing on their airline security analysis initiative and the impact of MANPADS on the airline industry. Our industry collaborations have resulted in three proposals, of which one (that included Boeing
input) is pending and the other two were not funded (one of which was led by an industry consortium that included Boeing and RAND). We have renewed our efforts to create closer ties to industry by creating an industry advisory committee, and have met individually with many additional companies.

In addition to hosting faculty from minority serving institutions and their students during the summers of 2005 and 2006, we also have developed a collaboration with Elizabeth City State University, a historically black university in North Carolina. Lloyd Mitchell, a faculty member at Elizabeth City State, will continue research that he began as a summer visitor in 2005 on risk of terrorism to Indian casinos, and begin a collaboration on the bioterrorism case study.

We believe that our intra-center and inter-center integration has been very successful. In particular, with CREATE taking the lead in two INC efforts, and with two ongoing inter-center collaborations, we fit into INC’s interdisciplinary, multi-institutional model. We were also successful in linking with the national laboratories, as a result of several CREATE researcher’s prior connections with the labs. Though our year one connections to the DHS operational units were not extensive, our year two approach of horizontal DHS networking has led to our integration with several DHS offices and we will continue to build on this network.

1.7 The Future of CREATE

Create aspires to be the leading national center for research and education in modeling, analyzing and managing the risks of terrorism other disasters. CREATE will be known for developing and applying an integrated methodology for risk and economic modeling and analysis. CREATE will also will be known for its unique mix of fundamental and applied research that has relevance for high-level decision making and policy setting. In addition, CREATE will be recognized as the lead institution for educating future leaders in addressing issues related to terrorism and other disasters.

To accomplish these objectives, we will increase our investments in economic modeling and analysis and focus on the integration of risk and economic assessment. We will also expand the center to include non-terrorist disasters and aspire to attract significant funding from non-DHS sources. Some specific plans for the future five years of CREATE are provided below. By 2010 we expect to have a mix of approximately 2/3 research on terrorism and 1/3 on natural disasters. Our goal is to double the current funding of CREATE to $8 million/year through additional funding by DHS programs outside of University Programs, and collaborations with the national laboratories, the NSF and industry.

Our plans for expanding the scope of risk assessment research are a direct result of our experiences in the first two years. During this period, we pursued two main approaches risk assessment: Traditional PRA and game theory. We encountered some difficulties with applying traditional PRA methods, but we also found some areas that are easier to execute. As a result, we plan to push the PRA frontier further along in the terrorism area, especially regarding the use of expert judgment, secondary probability distributions and sequential dynamic decision analyses. Game theory proved to be conceptually very useful and provided interesting results.
In the future, we plan to expand our game theoretic work to include dynamic and stochastic games.

For economic impact analysis, we have developed and used spatially disaggregated input-output models and CGE models. We also have expertise in econometrics, contingent valuation and cost-benefit analysis. In the future, we plan to conduct more research on behavioral aspects of terrorism. These include models of risk perception, behavioral responses to terrorism both ex ante and ex post, experimental economics, and dynamic games. In January of 2006 we conducted a one-day meeting with all CREATE economists and several outside economist to develop a research agenda for the next five years. The participants in this meeting identified the following topics:

- Understanding and measuring resilience in response to disasters
- Behavioral adjustments – ex ante and ex post – in response to terrorism
- Economic models of terrorists’ objectives and capabilities
- Improvements of economic impact models
- Bundling public goods to reduce terrorism risks
- Models of detection and indicators of terrorism events
- Public values and preferences for public and private measures to reduce terrorism risks

In the long term, we see a merger of risk and economic analysis, not by piecing the two approaches together as in Figure 1, but by truly integrating them in a dynamic, adaptive, stochastic modeling environment. Decision analysis, stochastic and dynamic games, and experimental economics will be used to integrate the risk and economics areas.

The case study model has worked well for CREATE – both internally by providing integration among research teams and externally by linking CREATE to clients at the DHS and elsewhere. We plan to continue this approach during the renewal period. In addition, we plan to add a short term response component to CREATE’s mission, including responses to DHS and other client’s needs that can be met with off-the-shelf tools in time scales of several months. We also would like to engage our partners at the operational units at the DHS in longer term collaboration (one year or more) to help them address significant problems.

We believe that we have a stable and successful management team in place and don’t see a need to make any major changes in the near future. The implementation of a new layer of leadership in risk assessment, economic assessment, and risk management will be tested in year three of CREATE. This new leadership structure will be combined with the creation of an executive committee consisting of the director, the three lead faculty and the directors of research, outreach, and education. This configuration will be considered as an experiment in the third year and evaluated at the end of it.

We have been very successful in recruiting and supporting research assistants, moderately successful in creating new courses and educational programs, but not very successful in recruiting students for the new programs and in engaging minority serving institutions. Our efforts in the coming years will be on these two less successful areas.
CREATE had a quick start in its outreach and communications efforts. Since research products require some time to be disseminated and transferred to the user community, we don’t yet have a strong record of transitioning our results to clients and users. However, we have many models, tools, and databases under development and we expect that the RAW platform will be our main vehicle to transferring CREATE models, tools, and basic knowledge to a broad range of clients and users.

We believe that our intra-center and inter-center integration has been very successful. We also were successful from the start in linking with the national laboratories as a result of several CREATE researcher’s prior connections with the labs. We had a slower start with connections to the DHS operational units, but we have engaged several DHS offices and we will continue to build on this network. We will expand our collaborations with minority serving institutions, seeking out research projects that are of interest to minority communities and to researchers associated with minority institutions.
2. RESEARCH ACCOMPLISHMENTS

2.1 Modeling Framework

The Center is developing and executing an integrated set of models and analyses, covering three research areas (Figure 1):

1. *Risk assessment* to improve the ability to estimate the threat, vulnerability, and consequences of terrorism
2. *Economic assessment* to improve the ability to assess the economic value of direct economic consequences of terrorism, to estimate indirect and induced consequences, and to conduct cost benefit and decision analyses to evaluate actions and policies to counter terrorism
3. *Risk Management* to support a risk-based allocation of resources to prevention, protection, and emergency response as well as to possible targets and threats.

This framework is very similar to the one outlined in the original CREATE proposal, but it has recently been aligned with related frameworks proposed by the DHS and the RAND corporation (three component risk assessment), and by the General Accounting Office and the National Academy of Sciences (separation of risk assessment and risk management).

![Figure 1. CREATE Research Framework](image)

We are developing modeling capabilities that span several threats and targets, represented by application areas. We have focused on specific application areas early in model development, to assure that the models are supporting actual decisions. We typically selected a case study for modeling and analysis in each application are:
• Attacks on people using weapons of mass destruction, for example, a detonation of a radiological dispersal device in a major port
• Weapon attacks on commercial aircraft, such as surface-air missiles (MANPADS), rocket propelled grenades or high caliber rifles
• Attacks on critical infrastructure systems, using conventional means, for example, multiple attacks on the nation’s electrical utility system

In the second year, the center concluded the above three case studies and pursued three new cones, selected because of their importance to national policy on homeland security:

• Investments to counter bio-terrorist threats, with respect to drug development, stockpiling of medical supplies, and distribution of medical supplies.
• Creating border security in the presence of the threat of weapon importation, while not impeding commerce.
• Risk-based allocation of resources across competing threats or assets, as in the distribution of federal grants to states and localities.

The modeling and application areas defining the work of the Center are organized in the matrix structure shown in Table 2a and 2b.

### Table 2a: Year 1 Case Studies

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2.2 Faculty and Research Products

Within this framework, CREATE has embarked on an ambitious research program that is already producing results. During year one, we conducted 20 research projects, which were linked through the three case studies of terrorist threats. During year two, we completed twenty year one projects, discontinued four projects, continued sixteen projects and developed eight new projects.

CREATE has engaged 35 tenure track faculty members at USC and its partnering institutions. Typically a faculty member receives a month or two for working on CREATE projects. Key faculty strengths are in risk analysis (Bier, Bank, Ross), decision analysis (John, Kleinmuntz, von Winterfeldt), economic impact analysis (Gordon, Moore, Richardson, Rose), economic benefits analysis (Lave, Smith), behavioral economics (Bostic, Redfearn), computer science (Tambe, McLeod), and operations research (Dessouky, Hall, Larson, Ordonez, Tien). The team includes one member of the National Academy of Sciences (Smith) and one member of the National Academy of Engineering (Tien). In addition to the tenure track faculty, CREATE has also involved 20 other Ph.D. level researchers, including four post-doctoral scholars. (Tables 3a and 3b).

CREATE researchers are highly cited. For example, ISI Web of Science citation index count data indicates that several CREATE researchers have achieved lifetime citation counts above 1000, including Peter Gordon, Richard Larson, Harry Richardson, Todd Sandler, Kerry Smith, Milind Tambe, and Detlof von Winterfeldt. Many more CREATE researchers have achieved citation counts in the high hundreds. Our research is making an impact through the organizations of several symposia at CREATE as well as at other national conferences. For example, CREATE organized three scientific symposia on risk and economic analysis and it co-sponsored several others.

The main intermediate research output of the CREATE team consists of publications, scientific presentations, and of CREATE-organized symposia. During the first two years, CREATE researchers produced 132 publications and gave 188 presentations. The 132 publications include refereed articles, non-refereed articles, book and proceedings chapters, and reports. All of them are either published, in print, accepted or under review. The break down is as follows:

- Six edited books and one edited journal
- 44 peer reviewed articles
- 56 book chapters or conference proceedings
- 25 CREATE reports

Other research products include models for risk and economic analysis and an integrated modeling environment, the Risk Analysis Workbench” (RAW). The risk analysis models include models software for specific risk applications, e.g., a decision analysis model to evaluate MANPADS countermeasures. A new economic impact model was developed, called NIEMO for National Interstate Economic Model, and model that determines the economic impacts of a terrorism event and disaggregates it spatially by the states in the US. RAW is the most ambitious software product, which is at one level a repository of all of CREATE’s models and tools and at another level a tool in itself that enables terrorism researchers across the country to access databases, risk and economic models, and exercised models.
### Table 3a. Faculty Members Involved in CREATE Research

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### Table 3b. Other Researchers Involved in CREATE

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<tr>
<td>Yao</td>
<td>Ke-Thia</td>
<td>Computer Scientist</td>
<td>USC</td>
<td>Information Sciences Institute</td>
<td>Ph.D.</td>
<td>Risk Management</td>
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<tr>
<td>Zach</td>
<td>Lorna</td>
<td>Assistant Research Scientist</td>
<td>UW-M</td>
<td>Center for Human Perf. &amp; Risk Analysis</td>
<td>Ph.D.</td>
<td>Risk Analysis</td>
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</table>
Table 4 lists the research reports and papers produced to date. Appendix B provides one-page summaries of the current research projects and budgets. Major project reports are posted on the CREATE website.

Table 4. Books, Journal Articles, and Reports

<table>
<thead>
<tr>
<th>Bier, Vicki / University of Wisconsin-Madison</th>
</tr>
</thead>
</table>
Dessouky, Maged / Fernando Ordóñez

Gordon, Peter / Harry Richardson / James Moore II

Hall, Randolph
33) Hall, R., & O’Sullivan, T., "External Terrorist Threats to Civilian Airliners: A Summary Risk


**Information Sciences Institute**


**Kleinmuntz, Don**


**Larson, R.C. / Structured Decisions Corporation**


**Masri, Sami / John Caffrey**


**McLeod, Dennis**


51) Chen, A., & McLeod, D., "Collaborative Filtering for Information Recommendation


Smith, V. Kerry / Research Triangle Institute

Smith, V., "Risk Perception, Optimism, and Natural Hazards", under review, 2005.


Tambe, Milind


**von Winterfeldt, Detlof**


86) von Winterfeldt, D. and O’Sullivan, T. “A Decision Analysis to Evaluate the Cost-Effectiveness of MANPADS Countermeasures.” Submitted to *Decision Analysis*.


**Zimmerman, Rae / New York University**


Postdoctoral Researchers


CREATE researchers have also provided testimony to or were members of several national committees related to homeland security. For example, von Winterfeldt testified before the House Committee on Homeland Security’s Subcommittee on Information Sharing and Terrorism Risk Analysis. He also was a member of the National Academies’ Board on Mathematical Sciences and their Applications and of the Committee on Defense Modeling, Simulation, and Analysis. Vicki Bier and Rae Zimmerman were on the EPA’s Homeland Security Advisory Committee of its Science Advisory Board. Peter Gordon, Bob Neches, Adam Rose, and Rae Zimmerman have also participated in committees of the National Academies. In total, CREATE faculty were represented on more than 18 major committees (see Table 5).

**Table 5. Membership in Major DHS Related Committees**

<table>
<thead>
<tr>
<th>COMMITTEE</th>
<th>INSTITUTION</th>
<th>TIME PERIOD</th>
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<tbody>
<tr>
<td>Vicki Bier</td>
<td></td>
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<tr>
<td>Homeland Security Advisory Committee, Science Advisory Board</td>
<td>Environmental Protection Agency</td>
<td>2005-</td>
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<tr>
<td>Peter Gordon</td>
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<tr>
<td>Committee on the Economic Benefits of Improved Seismic Monitoring</td>
<td>National Academies</td>
<td>2005</td>
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<tr>
<td>James Moore, II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methods for Determining Transportation and Economic Consequences of Terrorist Attacks</td>
<td>Transportation Research Board</td>
<td>2003-</td>
</tr>
<tr>
<td>Engineering Research Centers Blue Ribbon Panel</td>
<td>National Science Foundation</td>
<td>2005-2006</td>
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<tr>
<td>Bob Neches</td>
<td></td>
<td></td>
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<tr>
<td>Use of Information Technology to Enhance Disaster Preparation, Response, and Recovery</td>
<td>National Academies</td>
<td>2005-2006</td>
</tr>
<tr>
<td>Adam Rose</td>
<td></td>
<td></td>
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<tr>
<td>Economic Benefits of Advanced Seismic Warning</td>
<td>National Academies</td>
<td>2003-2005</td>
</tr>
<tr>
<td>Evaluation of the Second Generation Climate Policy Model</td>
<td>Environmental Protection Agency</td>
<td>2004-2006</td>
</tr>
<tr>
<td>Detlof von Winterfeldt</td>
<td></td>
<td></td>
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<tr>
<td>Committee on Defense Modeling, Simulation, and Analysis</td>
<td>National Academies</td>
<td>2005-</td>
</tr>
<tr>
<td>Homeland Security Council</td>
<td>Mayor’s Office, Los Angeles</td>
<td>2005</td>
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<tr>
<td>Committee on the Transportation of Nuclear Waste</td>
<td>National Academies</td>
<td>2003-2006</td>
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<tr>
<td>Board on Mathematical Sciences and their Applications</td>
<td>National Academies</td>
<td>2004-2006</td>
</tr>
<tr>
<td>Rae Zimmerman</td>
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<tr>
<td>Homeland Security Advisory Committee, Science Advisory Board</td>
<td>Environmental Protection Agency</td>
<td>2005-</td>
</tr>
<tr>
<td>Mitigation Planning Council</td>
<td>NYC Office of Emergency Management</td>
<td>2005</td>
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<tr>
<td>Committee on the Review and Evaluation of the Army Chemical Stockpile Disposal Program</td>
<td>National Academies</td>
<td>2002-2004</td>
</tr>
<tr>
<td>Electorate Nominating Committee of the Section on Societal Impacts of Science and Engineering (X)</td>
<td>AAAS</td>
<td>2004-2006</td>
</tr>
<tr>
<td>Rebuild NY/America Task Force</td>
<td>Bond Market Association</td>
<td>2001-2003</td>
</tr>
<tr>
<td>Committee of Visitors for the Decision Risk and Management Sciences Program</td>
<td>National Science Foundation</td>
<td>2004</td>
</tr>
<tr>
<td>Review Committee for the National Research Council’s Board on Infrastructure and the Constructed Environment</td>
<td>National Academies</td>
<td>2005</td>
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</tbody>
</table>
2.3 Risk Assessment

Risk assessment covers the modeling and analysis activities associated with the assessment of threats, vulnerabilities and consequences of major terrorist attacks. In the threat assessment step scenarios of terrorist attacks are developed and their probabilities are estimated. Vulnerability assessment is concerned with the likelihood of a terrorist attack being successful, due to weaknesses of the site or system under attack. Consequence assessment consists of modeling and analysis activities to predict the consequences of a successful terrorist attack, for example, in terms of fatalities and economic impacts.

For example, the risk assessment team studying dirty bomb attacks in the ports of Los Angeles and Long Beach identified 36 attack scenarios, completed a qualitative probability assessment of their relative likelihood, assessed the likelihood of success, if an attempt was made, and determined the likely source term of radioactive material that would be dispersed. In addition, using plume models from the National Atmospheric Research Advisory Center (NARAC) at Lawrence Livermore Laboratories, health consequences and the cost of decontamination were determined.

In addition to the support of the case studies, the risk assessment team conducted several cross-cutting activities:

- Todd Sandler of USC completed a major project examining the worldwide occurrence of transnational terrorist incidents subsequent to 9/11, and has documented the growth in terrorism in several world regions; Sandler also completed an analysis of two anti-terrorism policies, deterrence versus preemption, when a nation’s people and property are in jeopardy at home and abroad. The study underscored the need for nations to coordinate not only their deterrent countermeasures, but also their preemptive or offensive countermeasures. Independent actions by nations against a common terrorist threat will limit the effectiveness of such actions.

- Vicki Bier and her colleagues at the University of Wisconsin, Madison, developed game theoretic methods for investigating the effects of one agent's defensive investments on the incentives faced by other defenders. They also expanded existing tools and techniques of risk analysis to more effectively address security considerations, taking into account the fact that terrorists can observe our defenses and adapt their strategies accordingly.

- Detlof von Winterfeldt and Vicki Bier organized a state-of-the-art workshop on terrorism risk assessment held in January, 2005, which will lead to a special issue of the journal Risk Analysis to be published in 2006.

- Randolph Hall applied robust optimization techniques to represent adversarial risk within a game theoretic model. The project addresses risk assessment and management in an environment involving large uncertainties, adversarial and highly dynamic decisions. Progress was made in demonstrating the existence of an equilibrium solution, and a sample equilibrium calculation achieved on a small example.

- Detlof von Winterfeldt developed project risk analysis tools to assess the success probabilities of planned terrorist attacks, and applied them to a dirty bomb attack on the Ports of Los Angeles and Long Beach, and to evaluate the cost effectiveness of MANPADS countermeasures.
Rae Zimmerman reviewed vulnerability assessment methods, especially in the area of infrastructure protection. She directed her efforts to estimate consequences of electric power outages from terrorist attacks. The key areas addressed were to (1) Construct databases (2) Develop and run statistical models (2) Determine vulnerable components and areas, and (3) Develop economic cost estimation tools for outages.

As a cross-cutting activity, we are developing an integrated family of software tools, linked through the Risk Analysts’ Workbench (RAW) that utilizes a geographic-information-system (GIS) for data integration and display. When fully developed, RAW will provide risk assessment support for four classes of decision-making, as described below.

Risk-Based Resource Allocations: Distribution of a given budget among a set of alternative expenditures, such as allocation among drug development programs to counter biological weapons, federal grant allocations to states and localities, and funding distributions among alternative classes of threats or targets.

Threat-Based Investments and Policies: Based on an identified threat and vulnerability, a programmatic decision addresses whether to broadly invest in measures to protect against a class of threats, such as whether to install counter-measures against missile threats on aircraft, whether to develop an information sharing program among law enforcement agencies or implement control measures on visitors to the United States.

Site or Asset Specific Investments: A targeted investment is intended to protect against threats at an individual location, such as installing a security barrier or monitoring equipment, employing security personnel or developing the capability to effectively respond to terrorist caused disasters.

Acting on Pieces of Intelligence: Based on a collection of evidence, a decision is needed as to whether to initiate an investigation, which could range from inspection of a cargo shipment or airline passenger to a criminal investigation of a suspected conspiracy.

RAW was the major initiative in tool integration. RAW is an approach to serving risk analysts in a common framework, enabling synergies which help both more effectively perform their roles in assessing terrorism threats and evaluating strategies for countering those terrorist threats. Its coverage spans risk assessments and models, decision support tools, scenario and threat definitions, supporting data, and presentation and review tools. The workbench will be capable of integrating different risk and consequence models in a common user and data set management interface. The user interface will allow for the creation and specification of new scenarios and models for analysis, management of existing scenarios, sharing of scenarios among multiple analysts, roll-up into composite analyses, and review of combined scenarios by policy developers and decision makers.

RAW’s primary objectives are to:

- Establish a server containing CREATE risk models and decision-support tools, databases, scenario definitions, supporting documentation, and assessment results/reports
- Develop the initial common-look-and-feel user interface (UI).
- Develop an initial prototype that includes the models, tools, data, and current risk assessments of the initial CREATE Aviation Threats (MANPADS) case study.
- Extend the prototype to include the tools, data, and information to support research and decision-support analysis for the Year 2 case studies in bioterrorism and border security threats.

RAW’s major products will be prototype software that will support the review of risk analyses such as MANPADS threats, selected bioterrorism threats, border security threats, and future threats to be determined. The intended customers include DHS, state and local government researchers and decision-makers.

2.4 Economic Assessment

CREATE’s conducted several economic modeling and analysis activities to support assessments of the economic impacts of terrorist attacks. As a unifying effort, CREATE organized a series of symposia on the state-of-the-art of economic modeling of the impacts of terrorist events. These symposia brought together a wide range of economists interested in terrorism. The papers presented at the first symposium have been published in an edited book released in late 2005. The book including the papers of the second symposium is planned for publication in 2006.

The symposia showed that there are multiple and complementary approaches to modeling and analyzing the economic consequences of terrorism. These include input-output models, computable generalized equilibrium models, hedonic pricing models, and game theoretic models. CREATE involved economists in these different approaches and supported them in exercising their models in specific scenarios. For example, an input-output model was applied to the economic effects of a long-term port shutdown and specific estimates of the economic costs due to business interruptions were obtained. An exploration of the use of cost-benefit analysis on some of the CREATE case studies was also conducted.

The economic analysis projects conducted included:

- Peter Gordon, James Moore and Harry Richardson developed a national economic model to evaluate the business disruption effects of terrorist attacks. The model was applied in a report supporting the port case study, and used to evaluate a range of terrorist scenarios, including radiological devices in the Los Angeles financial district, major theme parks, and a shutdown of the commercial air system.
- Lester Lave led an economic analysis of the effects of weapon attacks on commercial aviation, examining a comprehensive set of impacts as well as on an attack on the electric power system.
- Adam Rose utilized a generalized equilibrium model to evaluate the economic impacts of electricity supply disruptions. The work served as proof of concept of the application of a computable general disequilibrium model to estimate the business disruption impacts of a terrorist attack on the electricity power system.
- We executed an agreement with Kerry Smith, through the Research Triangle Institute (RTI), to examine individual risk perceptions and people’s willingness to take
personal actions to protect themselves against terrorism vs. investments by the public sector.

- **Larry Samuelson** and **Vicki Bier** extended prior game-theoretic models for allocating defensive investments by representing uncertainty about attacker preferences—namely, which targets will be most attractive to attackers. This model yields hedging at equilibrium—spreading of defensive investments among a large number of targets with a non-zero probability of being attacked. The model has significant implications for decision-making, and in particular supports risk-based allocation of defensive investments.

### 2.5 Risk Management

CREATE has five current projects in the area of risk management, all of which have produced both reports and software. Three of these projects are concerned with emergency planning and response. Two are more broadly concerned with risk management issues related to the CREATE case studies and the development of a general risk management framework.

CREATE has three emergency response projects. One project, led by Richard Larson of Structured Decisions Corporation, is developing software tools for dispatching emergency personnel to catastrophic events. The project builds from Dr. Larson’s pioneering research in the use of queuing models to create dispatch plans for police and fire agencies. Dr. Larson and his colleagues have produced several publications and reports on their work, including one documenting the state-of-the-art in dispatch planning, another providing case studies in disaster response, and a third the *Updated Desktop Hypercube™ Design Document*. A condensed version of the state-of-the-art report appeared in the magazine *OR/MS Today*. A major result of this effort is the development of a software tool for emergency response planning.

In a second emergency planning and response project, Maged Dessouky and Fernando Ordonez, both of USC, are developing software tools for stockpile and allocation of emergency supplies, such as pharmaceuticals for possible bioterrorism events. This work is leading to an emergency supply chain model, to enable quick reaction to major terrorist incidents, particularly biological attacks. The work covers models that can be used to aid emergency responders in selecting (1) appropriate staging areas, and (2) suitable routes to distribute vaccinations to the staging areas.

The third project, led by Milind Tambe in cooperation with USC’s Integrated Media Systems Center and Institute for Creative Technologies, is developing multi-media training tools for response personnel, to assist in response to major incidents. The simulator is being developed in collaboration with the Los Angeles Fire Department, which is helping enhance model realism. The combined effort is enabling CREATE to be a leading center for research on methods and tools for minimizing the negative consequences of terrorist attacks. Prototype software is now available for all three projects.

CREATE has leveraged its work in emergency panning and response with the Los Angeles County Department of Health Services. Randolph Hall, Maged Dessouky and David Belson initiated a project to develop the LA County plan for distribution of the Strategic
National Stockpile in the aftermath of a biological incident. Separately, the same team is working with the LA County General Hospital on a comprehensive analysis of patient flow improvement, to reduce delays in receiving treatment. LA County General has the busiest emergency department in the country, and would be a critical resource in responding to any major terrorist attack in the region.

In addition to these projects, Rae Zimmerman and her team at NYU is developing a more generic analyses frameworks for risk management. Rae Zimmerman’s work includes projects on investments in infrastructure protection and border security.
3. APPLIED RELEVANCE

While CREATE focuses on medium and long term research that advances the knowledge base and the intellectual capacity of our nation to counter terrorism, we also are committed to make a difference in the short and medium term policy debates. To accomplish this, CREATE has used an approach that encourages the application of fundamental research ideas to specific problems relevant to the DHS and the Nation. CREATE teams accomplish this by conducting several case studies each year. Case studies are presented as terrorism issues or problems faced by the DHS or other agencies. Tables 2a and 2b show the case studies selected in the first two years.

Case studies were selected in close interaction with CREATE’s scientific advisory committee (SAC), which includes DHS staff ex officio. Criteria for case selections are the importance of the issue to the DHS, the likelihood of scientific advances in the context of the case study, and the expertise of the CREATE team relevant to the case study. The CREATE team usually proposes 5-6 candidate case studies and selects three based on guidance of the SAC. Following are the results of the first six case studies.

We also have developed software in support of decisions to be made in the context of these cases. These software products are discussed later in this section.

3.1 Case Studies

3.1.1 Aviation Threats

CREATE is analyzing investments aimed at improving commercial aviation safety by reducing the threat and consequences of external portable weapon attacks aimed at civilian aircraft. While our team studied a variety of weapons, the main model and analysis tools were developed to evaluate the cost-effectiveness of defenses against infrared-seeking surface top air missiles known as MANPADS (Man Portable Air Defense Systems).

Risk Assessment  Two reports were completed – one public and the other “official use only” – that document the occurrence, proliferation, capabilities and counter-measures for a wide class of weapons that threaten commercial aviation—including MANPADS, high caliber rifles and rocket-propelled grenades. We have evaluated the applicability of each counter-measure to each weapon class. We have also developed threat scenarios for weapon attacks on commercial aviation based on this study, defined by location of attack, weapon type, number of attacks and counter-measures in place. In addition, we have developed a simulation model for estimating the probability that an attack would succeed based on the characteristics of the weapon, the ascent or descent path of the aircraft, and the attacker location (or location strategy). Regarding consequences of terrorist attacks on the aviation system, we developed a commercial aviation simulator to evaluate and design response strategies to aviation threats, particularly with respect to re-routing aircraft to avoid risks. We also developed aircraft survivability models for commercial aviation. Prototypes of both models were completed early in the summer of 2005 and made available for further analysis by DHS.
Economic Assessment. We conducted two economic analyses. The first was based on an input-output model of the economic impacts of a major MANPADS attack with consequences similar to those of 9/11. The second analysis used consumer surplus considerations to estimate the costs of a nationwide shutdown of the aviation system. Both analyses also suggest very high costs, between $1 billion and $2 billion per day for a complete shutdown and up to $400 billion for economic impacts due to reduced passenger volume for two years.

Risk Management. The project was completed with a comprehensive assessment of weapon threats to commercial aviation, combined with a cost/benefit assessment of alternate countermeasures. The report describes the decision analysis to assess the cost-effectiveness of MANPADS countermeasures. These countermeasures are electronic devices that can be installed on commercial airplanes to detect and deflect surface-to-air missiles (SAMS) fired by terrorists. The model considers a single or multiple terrorist attack to shoot down a commercial liner with a heat seeking (SAM).

The analysis occurred in two stages: First, a decision tree model was built using the TreePlan software and all inputs were parameterized to cover a wide range of reasonable possibilities. A Visual Basic interface was established to create a user-friendly and interactive tool to explore alternative sets of parameters. Use of this tool suggested that the probability of an attack, the total economic costs due to the attack, and the cost of the countermeasures were the key drivers of the decision of whether or not to equip commercial planes with MANPADS countermeasures.

Subsequently another model was built in Treeage Pro, a tool that is especially valuable for sensitivity analysis. The Treeage Pro model is also completely parameterized to account for the type of weapon, the type of aircraft, the location of delivery of the weapon, distance from the airplane, and possible countermeasures. While the model focuses on one attack, it can easily be adopted to multiple and possibly sequential attacks. The analysis suggests that countermeasures installed on planes to deflect heat seeking SAMs can be cost-effective, if the probability of such an attack is large (>0.5 in ten years), the losses are large (> $100 billion), and the countermeasures are relatively inexpensive (< $15 billion).

3.1.2 Ports and Dirty Bombs

This case study evaluates mechanisms to improve port security and to reduce the threat of radiological weapons by examining the threats, vulnerabilities, and consequences of a dirty bomb attack on the Los Angeles and Long Beach harbors.

Risk Assessment The risk assessment team developed 36 threat scenarios defined by the sources of the radioactive materials used, the transportation modes, and the point of delivery of the bomb. A qualitative assessment of the likelihood of these scenarios was conducted, which resulted in the selection of three representative, plausible, and relatively likely scenarios. For example, one scenario involves the theft of radioactive materials from an industrial irradiator containing about 200,000 curies of radioactivity. Each of these scenarios was analyzed using standard project risk analysis tools to determine the likelihood of success, if terrorists were to attempt an attack similar to this scenario. This analysis provides an upper bound on the
probability of this type of event (since it does not include the probability that this scenario is actually attempted). The risk analysis ends with the so called “source term” of dispersed radioactive material – large particles or clumps that fall down close to the detonation side, fine particulates that disperse into the air, and aerosols. A major part of the consequence assessment was conducted in collaboration with NARAC (National Atmospheric Release Advisory Center) at Lawrence Livermore National Laboratories. NARAC has the capability to generate plume predictions based on the source term, wind direction and weather conditions. NARAC has provided plumes for our scenarios and we have used these plumes in our assessments of economic and other consequences.

Economic Assessment. One “hand-off” from the risk analysis to the economic modeling team was to provide the number of days of a port shut down. As bookends, we asked the economic modelers to consider scenarios ranging from two weeks to four months. The result of a major input-output modeling exercise was that a two week shut down would cost the regional economy about $350 million, a four month shut down would cost the economy $34 billion, and a one year shut down would cost $100 billion. Other significant costs are due to evacuations and business losses in the plume area (up to $5 billion) and due to decontamination and disposal of radioactive materials (up to $20 billion).

The results were documented in a CREATE report. Using the above risk and economic analysis methods, the paper begins by identifying the most likely dirty bomb attack scenarios in terms of sources of radiological material, delivery modes and detonation sites. A project risk analysis is developed for selected scenarios to identify the tasks terrorists need to perform to carry out this project and to determine the probability of the project’s success. The consequences of a successful attack are described in terms of human health effects and economic losses. The findings show that the chances of a successful dirty bomb attack are lower than expected and the health consequences of even a major attack are relatively small. However, the economic consequences from a shutdown of the harbors could result in significant losses. The implications of detecting, intercepting and countering a dirty bomb attack are discussed.

Risk Management. The main risk management implications relate to the communication of the long-term risks of exposure to radioactivity, the necessary decontamination costs as related to clean up standards and policies, and the implications of low level residual radioactivity in possible large areas and the associated business impacts. The analyses considered policies regarding prevention (protection of radioactive materials at the source), protection (radiation portals to prevent radioactive materials to enter the ports), and emergency response and recovery (evacuation policies and policies regarding decontamination).

3.1.3 Electricity

This case study focused on methods to ensure the security of critical infrastructure and the activities it supports by evaluating mechanisms to improve the security of the nation’s electrical supply system. The case applies risk, consequence and economic accounting procedures to electric power. Scenarios and choices are presented for each of these three areas of analysis and are integrated to evaluate a wide range of alternative conditions driven by electricity disruption, potentially affecting the economy.
Risk Assessment. To characterize risks of attacks on critical infrastructure via electric power, we have used both statistical and case-based analyses to identify ways in which the grid is vulnerable to attack and the odds and characteristics of outage events. First, the team has conducted an in-depth analysis of grid composition and configuration and its vulnerability. On this basis, a number of scenarios were created and linked to actual urbanized areas to assess consequences and economic impact. The most extreme scenario is a grid configuration in which (1) transmission lines are constrained along only one or two routes (2) only a few very large substations and transformers are connected to transmission and (3) no in-region capacity exists to produce independent electric power in the event of an outage. In this scenario, disruptions occur at the transmission, substation (transformer), and generation levels simultaneously. Second, in support of the grid vulnerability analysis, component failure modes were identified by analyzing and comparing international terrorist attacks on electric power facilities (200 events) and a U.S. data set of electric power failures from 1990-2004 (400 U.S. events and 513 including Canada) using an “all-hazards” approach. Comparing terrorist and non-terrorist disruptions allows common failure modes to be identified at the component level for a qualitative assessment of threat and risk as input to grid vulnerability. Third, a key outcome of the statistical analysis is estimating the odds of an outage occurring with certain characteristics. Results from the U.S. data indicate that the odds that an outage event will occur increases by about 9% per year, and the odds that duration will increase is about 14% per year. This approach provides predictive capability for anticipating the outcomes and causal factors in electric power outages.

Analyzing the attributes of the outage databases described above guides the assessment of consequences and economic effects of outages to other infrastructure and direct consequences to electric power. The latter includes the MW of demand lost, duration, customers and suppliers affected, and primary cause. Consequences to other infrastructure are identified through operational, case and literature reviews, including those involving comparable catastrophic events, such as the August 14, 2003 blackout (involving 50 million customers and a duration of at least 24 hours). The infrastructure impacts of the August 2003 blackout included inoperative city water supply systems in Cleveland and Detroit, with local water outages for systems relying on pump-driven wells and pumping to high-rise buildings; outages of oil refineries and pipeline networks, gasoline pumps, electrified rail transport systems and traffic lights, among many others. After general consequences were identified, specific consequences were linked to geographic areas associated with the grid scenarios as an input to economic accounting. The consequence assessment also incorporates methods to quantify interdependencies among critical infrastructure systems, and explicit indicators of interdependency to predict the extent of consequences.

Economic Assessment. The critical infrastructure team adopted an economic accounting approach for electric power outages and other affected critical infrastructure and businesses. Three areas were evaluated: human premature death and injury; business losses; and costs associated with public service disruption. A detailed set of economic cost estimation factors was developed and quantified on the basis of literature review, operational data, and data from extreme events. Cost estimates for congestion and traffic in the New York metropolitan area were also calculated to be $2 billion for a 24 hour blackout. Costs in terms of deaths, business losses, or public service disruption (congestion) for a 24 hour blackout could be far greater if civil unrest and deliberate secondary attacks occurred that take advantage of the outage. The utility of various economic models for electric power failures is also being reviewed and...
assessed. A modeling effort for the State of New Jersey determined the economic impact of a devastating outage in that state.

**Risk Management.** The general conclusions of this work are that:

- Databases of non-terrorist outages and statistical models provide the basis for a tool for identifying vulnerable grid scenarios and developing terrorism scenarios for risk and consequence assessment
- Three components are viable economic cost estimators - premature deaths, business loss, and transportation disruptions. Statistically based models provide an important tool for inputs into the business loss component of economic cost estimates for electric power outages. Simpler equations are also tools to estimate cost of premature deaths and transportation congestion.
- Applying these tools, however, indicates that civil unrest, another attack taking advantage of the outage, or severe cascading effects would have to accompany a 24-hour outage to produce costs equivalent to a major catastrophe, such as September 11.

### 3.1.4 Bioterrorism

This case study consists of several analyses of bioterrorism risks and evaluations of the cost-effectiveness of countermeasures.

**Risk Assessment.** The risk assessment projects focus on the “front end” of a bioterrorism attack, which is the weakest part of bioterrorism risk assessment. We are working closely with the National Biodefense Analysis and Countermeasures Center (NBACC) and their risk assessment teams. Eventually, we hope to contribute to a suite of risk assessment models that combines the best efforts of CREATE and of NBACC.

To assess the threat of a biological attack, we need to address the motivation and capabilities of terrorists to use biological agents to attack the US. In the bioterrorism case study, we are developing models to assess motivation and capabilities to predict terrorists’ preferences for biological agents. Since our understanding of motivation and intent is uncertain, our predictions of terrorists’ preferences are also uncertain. We will incorporate uncertainties in both the terrorists’ preferences and capabilities to predict probabilistic preferences of biological agents. These probabilistic preferences will serve as a proxy for the probability of a terrorist group choosing a particular agent.

To assess the vulnerabilities of the US to a bioterrorism attack, we need to understand the likelihood that a planned attack is successful. We will continue to use the project risk analysis tool developed at USC to assess this probability, as we have done in the past for a dirty bomb attack. In this case, we will choose an anthrax attack using scenarios that involve either weaponized of non-weaponized anthrax and large vs. small production and release.

The consequence assessment part of this analysis will be conducted in close collaboration with NBACC. The NBACC contractors have developed sophisticated consequence models that can be used for this purpose.
Economic Assessment. With additional funding from NBACC, we will conduct several economic analyses of bioterrorism events. A key distinction is between biological agents that are contagious and those that are not, for example, smallpox vs. anthrax. Contagious agents may kill many people, cause sicknesses, and require quarantine zones. The main effect will be a possible large loss of labor force and loss of productivity. Non-contagious agents like anthrax may kill people and cause sicknesses, but its main effect will be to make areas of buildings or even blocks of cities uninhabitable until decontamination is completed. The economic impacts in this case occur through the large decontamination cost and the inability to use the contaminated areas. We are beginning to build prototype economic impact models for both cases.

Risk Management. The main risk management options in the bioterrorism areas are early detection, rapid vaccination, isolation and quarantining. In a joint study with the California Department of Health Services, we are assessing the cost-effectiveness of the indoor biowatch program and an example of a risk management option. We are also studying the medical delivery and distribution system.

3.1.5 Border Security

This project seeks to evaluate alternative policies and technology solutions for protecting our borders against illegal importation of weapons, terrorist infiltration and direct terrorist attacks while maintaining our competitiveness in international trade. The scope of the project covers maritime, land border and aviation security. It is our intention to develop a systems based risk management approach that integrates border security operations and performs comparative risk assessment between different elements of the system to support fund allocation decisions. To this end, we are conducting a comprehensive overview of threats and border vulnerabilities. We will examine alternative strategies, including methodologies for screening and inspecting cargo, and operational improvements that promote participation in trusted shipper programs.

A particular focus will be on protecting the nation against importation of nuclear materials and weapons. So far, funds for detecting and intercepting these materials have been appropriated with little attention to risk comparison or recognition of the adaptive nature of terrorist strategies. We are developing a systems based risk management approach that models the border security as a collection of sub-components that forms a system achieving a common objective. A central decision maker is assumed to choose among a set of investment and policy alternatives, each associated with respective costs of implementation. Benefit of each investment and policy is measured by the reduction in risk exposure of the overall system, rather than the reduction of risk on a particular component. Component risks are interdependent as terrorists formulate their strategies to exploit vulnerable points of defense systems. We believe that this modeling approach will eliminate any investment strategy that allocates limited funds with minimal risk comparison across the whole system.

In addition to the system wide assessment, we also will conduct a specific analysis of policies for inspecting container cargo at the Los Angeles harbor. This study is connected to a proposed collaboration of CREATE with several contractors to develop and manage a container
inspection facility at the LA harbor. Our specific contributions to this project will be in the development of a logistics plan for inspection procedures and, in particular, using signal detection models to determine optimal inspection strategies.

Risk Assessment – The objective is to develop and apply risk factors and measures reflecting vulnerabilities unique to infrastructures at border crossings as inputs for threat, vulnerability, and consequence assessments. Tasks include:

- Identify U.S. border crossings from government/trade documents and literature
- Develop criteria for infrastructure importance and vulnerability to being attacked at border crossings, in terms of their role in sustaining border activity, volume of activity, infrastructure asset value, value of commodities shipped, and uniqueness (non-redundant configurations) to prioritize border crossings for more in-depth study.
- Using criteria identified in item b, screen and select a set of border crossings for in-depth study of the dependency of the borders on infrastructure
- For selected crossings and key infrastructures at those crossings, identify detailed infrastructure facilities and activity
- Characterize key infrastructure vulnerabilities in the context of an attack (based on or in terms of factors that include criteria above), netting out security measures now in place
- Include the role of critical infrastructure interdependencies as contributors to vulnerability and as a basis for prioritizing those vulnerabilities

To assess the consequences of terrorist attacks, we will develop a set of scenarios that reflect the impact of hypothetical attacks on border infrastructure

- For infrastructure at selected crossings, develop measures of and data for consequences should borders be attacked; define parameters and obtain data e.g., on volume of people, goods and services movement, capacity, value as consequence measures.
- For each selected crossing, prioritize critical infrastructure according to potential consequences
- Define scenarios based on alternative modes of attack on prioritized infrastructure at border crossings
- Identify consequences for each scenario, e.g., shipment volume/value (for economic impact)

Economic Assessment. The economic assessments consist of two parts: assessment of the economic impacts of a possible border breach (e.g., import of radiological materials) and a subsequent successful terrorist attack; and the economic costs of mitigation measures (e.g., stricter inspection regimes).

Regarding the economic impacts of a border breach and subsequent terrorist attack, we are using CREATE’s past economic assessments of border related impacts, e.g., the shutdown of several airports and seaports in the US. We will also draw from the work by CREATE teams
and by others to assess the economic impacts of specific scenarios (e.g., an anthrax, a nuclear bomb, or a radiological dispersal attack).

Regarding the cost of border protection, we will use the existing literature and, if necessary, develop or own models of the cost of border protection. For example, there are several RAND analyses of the costs of container inspection regimes. Delay in processing people and goods at the borders are a key issue in these analyses.

**Risk Management.** In the context of border security, our risk management framework consists of developing a set of alternatives for improving border security, conducting a decision analysis of their cost-effectiveness in reducing threats, vulnerabilities, or consequences, and developing guideline for implementing and monitoring the preferred alternatives.

In the specific context of container security at the Los Angeles port, we will be conducting an analysis of alternative inspection regimes, using both logistics analyses to determine possible delays and the associated costs and signal detection analysis to determine the rate of false alarms, and correctly identified contraband and the associated costs and benefits with both.

### 3.1.6 Risk-Based Resource Allocation

DHS Secretary Michael Chertoff has frequently stated that allocations of homeland security resources must better reflect the effectiveness by which these resources reduce risk. In this context, he frequently refers to risk as consisting of threat, vulnerability, and consequences. The application of risk analysis to resource allocation decisions is particularly relevant to grants under the “Homeland Security Grant Program” (HSGP). These grants provide resources for training, planning, equipment, and exercises to states and local jurisdictions in their efforts to prevent, plan for, and respond to acts of terrorism. The current formula for assigning these grants to States consists of a mix of an equal proportion across all States plus a “risk-based” portion, which is primarily based on population density. This formula has been the source of much criticism by State representatives, especially those representing states which are target rich and could be considered “high-risk.”

One of the purposes of this case study is to examine alternatives formulas for allocating funds to States, targets and sites. During the first year of the grant, we concluded a major review of the current and alternative proposals for this purpose. This analysis concluded that:

- Any proposed risk-based solution for allocating funding will require a nation-wide systematic assessment of risk and vulnerability.
- The development of a nation-wide standardized methodology for assessing terrorism risk must include evaluation of state-wide “best practices”.
- The development of a risk assessment methodology naturally extends beyond identifying targets and requires estimation of probabilities and consequences to guide funding decisions.
• Given the mission of first responder grant funding, it is critical that investment is uniformly distributed across functions to prevent, deter, respond to and recover from threats and incidents of terrorism.
• Any risk-based solution must engage both private sector stakeholders and public sector elected stakeholders.

In the second year, we are expanding our effort to develop a “bottom-up” risk-based allocation approach and associate methodologies that begins with a list of assets, assesses their status quo risks, and the examines the cost-effectiveness of allocating funds to better protect these assets. As a special case, we are examining 12 major assets in California to conduct this analysis.

**Risk Assessment.** Any risk-based allocation must start with a portfolio of sites (targets or assets) that are to be protected, a risk assessment with no additional investment in protection and risk assessments at various levels of protection. This task can be very time consuming and data intensive and we are building on existing modeling and risk analysis efforts and expert judgments to generalize beyond the existing assessments.

To be specific, we are looking at a limited number of sites in California to conduct the assessments of their risks and the reduction of risks due to investments in protective actions by first responders. This work is done jointly with the California Office of Homeland Security and coordinated with the DHS Office of Infrastructure Protection. We are working with LLNL and AIR International to determine how to best use their risk assessments for these sites in California. We plan to use expert panels to assess the effectiveness in risk reduction, given investments in these sites and also to extrapolate to sites for which no risk assessment has been conducted (for example, to extrapolate from one petrochemical plant to another).

A related activity, led by Rae Zimmerman and her team, explores the vulnerabilities of selected infrastructure systems, based on their value, location, and capacity. This project will develop vulnerability criteria and a database of infrastructure vulnerabilities based on an assessment of infrastructures on these criteria. In addition, Vicki Bier’s team at UW-M is examining resource allocations in particular buildings, using game theoretic approaches.

**Economic Assessment.** Regarding the economic assessment, we will use existing literature and estimates of the National Laboratories to determine the economic effects of an attack on each of the sites under consideration. In some cases, we have existing CREATE economic assessment, e.g., on the economic consequences of a shutdown of the sea ports, airports, or of selected tourist attractions. In other cases we will build models of the economic consequences, e.g. of shutting down the public transportation system in the Bay area. Yet in other cases, we will use expert panels to extrapolate from the economic consequences of one event to another one.

**Risk Management.** To facilitate the evaluation and optimization of resource allocations across sites or assets, we will work closely with Don Kleinmuntz and use an existing resource allocation software tool, STRATACAP, that he developed.
We will first use the risk-based allocation tool to optimally allocate a given HSGP grant to the State of California, based on the risk-based prioritization of 20-30 sites and assets in this state. In addition, we will develop algorithms of how to apply a similar methodology to other States and how to allocate HSGP grants across states. We will compare this allocation algorithm with the current allocation algorithm and some other competitors and make recommendations regarding the advantages and disadvantages of alternative allocation schemes.

3.2 Models and Software Products

In addition to the publications related to the case studies, we also developed software to support specific decisions. These software products are listed in Table 6. Our primary software integration effort is the Risk Analysts’ Workbench (RAW). RAW enables both decision-makers and risk analysts to use risk analysis tools, models, data, analysis and results, each in their unique roles and needs in risk-sensitive planning. RAW will provide access to different risk and consequence models in a common user and data set management interface. The user interface will allow for the creation and specification of new scenarios and models for analysis, management of existing scenarios, sharing of scenarios among multiple analysts, roll-up into composite analyses, and review of combined scenarios by policy developers and decision makers. The first version will incorporate all the MANPADS analysis conducted by CREATE, and the AusSpread Model and analysis from the National Center of Foreign Animal and Zoonotic Diseases Defense (FAZD) center.

Another example of a useful tool developed and delivered by CREATE is the MANPADS tree software. This tool develops the event trees for scenarios of terrorist attacks on civilian aircraft using shoulder-fired missiles. The tool was developed using commonly available commercial software, and made available to the Countermeasure MANPADS DHS office. The tool flexibly and easily accommodates user estimates of probabilities, and calculates real-time the changes in the risk and economic consequences of events, quickly enabling visual and quantitative cost-benefit analysis of countermeasure effectiveness.

Another example is the SDC emergency response planning software – based on the Hypercube queueing model – developed to the state of demo-readiness. This is a freely available, downloadable planning tool for municipal administrators to plan for response to large events in their communities. This tool will be use in a case study of the City of Boston, and we have the commitment of Boston Police Commissioner, Kathleen O’Toole, to participate in the study and support SDC’s research efforts. The case study will link an explosive terrorist attack to Boston-area hospital surge capacities (i.e., surge capacity is the increased capacity for a hospital to treat patients arising for a low-probability, high-consequence event). We will use the Transient Hypercube Queueing Model (THQM) to provide the logic for the emergency response.

Rae Zimmerman and her colleagues at NYU were highly productive in developing models and databases, as shown in Table 6. Of particular note, the NYU team developed an economic toolkit for assessing the potential economic costs associated with a terrorist attack on the electricity grid. These tools use the results of the statistics toolkit and estimate three types of economic costs: business losses, premature deaths and injuries and traffic congestion. They also compiled extremely useful databases of infrastructure locations and concentration, detailing the
locations of facilities, the capacities and usage of various infrastructures, including transportation (e.g., roadways, transit), energy (e.g., electricity), etc.

Vicki Bier and researchers at UW-M are developing numerical optimization model and software to address the allocation of defensive resources among cities (or other classes of targets). A numerical optimization prototype is currently in testing, with additional work underway to extend to larger numbers of targets. The model is currently being applied to RAND data on economic impacts of terrorist attacks, and could be further applied to CREATE infrastructure-density data being developed by NYU.

Additionally, other USC researchers have developed models and software tools to enable economic analysis (NIEMO), transportation and asset distribution software (TRANSOPT), and incident commander training (DEFACTO). NIEMO companion supply-side version and one that allows for input substitutions are being tested. TRANSOPT will integrate a full suite of calculational optimization tools. The DEFACTO simulation and training tool was also extended to include a serious game interface, and developed into its own version (FireScope: Incident Commander). All tools are being designed to be GIS interface-enabled.
<table>
<thead>
<tr>
<th>CREATE Project Leader(s)</th>
<th>Name of Product</th>
<th>Type of Product</th>
<th>Application Area</th>
<th>Intended User/Client</th>
<th>Specific Users/ Clients</th>
<th>Status</th>
<th>Other Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Orosz, Bob Neches</td>
<td>Risk Analysts' Workbench (RAW)</td>
<td>Software tool</td>
<td>Risk and Economic Analysis</td>
<td>Risk analysts and policy makers</td>
<td>CREATE, FAZD, and other researchers and policy-makers</td>
<td>Prototype Beta ready on 4/25</td>
<td>Prototype includes MANPADS and FAZD FMD disease spread model and decision-support tools</td>
</tr>
<tr>
<td>Detlof von Winterfeldt</td>
<td>MANPADS Trees</td>
<td>Model and Software Tool</td>
<td>Countermeasure cost-benefit analysis</td>
<td>Risk analysts and policy makers</td>
<td>Countermeasures MANPADS Office</td>
<td>Prototype developed</td>
<td>Prototype used by DHS in MANPADS countermeasure cost-benefit analysis</td>
</tr>
<tr>
<td>Vicki Bier</td>
<td>MANPADS Simulation</td>
<td>Simulation model and software</td>
<td>Countermeasure effectiveness analysis</td>
<td>Risk analysts and policy makers</td>
<td>CREATE</td>
<td>Prototype used - countermeasure effectiveness analysis</td>
<td>Includes spatial features that affect countermeasure effectiveness</td>
</tr>
<tr>
<td>Vicki Bier</td>
<td>Resource Allocation Software</td>
<td>Numerical optimization model and software</td>
<td>Resource allocation among cities (or target classes)</td>
<td>Risk analysts and policy makers</td>
<td>CREATE</td>
<td>Numerical optimization prototype in testing</td>
<td>Applied to RAND data on economic impacts of terrorist attacks</td>
</tr>
<tr>
<td>Gordon, Richardson and Moore</td>
<td>NIEMO</td>
<td>Model and Software tool</td>
<td>Multi-state, input-output economics analyses</td>
<td>Economics analysts</td>
<td>CREATE</td>
<td>Prototype used for economics analyses</td>
<td>Demand-side version of NIEMO applied to various economic impact studies</td>
</tr>
<tr>
<td>Richard Larson</td>
<td>Hypercube</td>
<td>Model and Software tool</td>
<td>Emergency Response Recovery Planning</td>
<td>City &amp; County emergency response planners</td>
<td>Boston Police Department</td>
<td>Prototype used in Field Tests</td>
<td>Case Study with Boston Police Department in preparation</td>
</tr>
<tr>
<td>Maged Dessouky, Fernando Ordonez</td>
<td>TRANSOPT</td>
<td>Model and Software tool</td>
<td>Constrained optimization of transportation asset distribution</td>
<td>Transportation, distribution, emergency response planners</td>
<td>Los Angeles County, other city and county planners</td>
<td>Optimization prototype used for LAC vaccine distribution plan</td>
<td>Used for Los Angeles County Strategic National Stockpile Transportation Plan (with David Belson)</td>
</tr>
<tr>
<td>Milind Tambe</td>
<td>DEFACTO</td>
<td>Simulation software</td>
<td>Incident commander training</td>
<td>Fire and police incident commanders</td>
<td>LA Fire Department</td>
<td>Prototype agent-based model in use</td>
<td>Serious training game under development with GamePipe Laboratory</td>
</tr>
<tr>
<td>Milind Tambe</td>
<td>PLANRAND</td>
<td>Model</td>
<td>Deterrence &amp; risk minimization</td>
<td>Security officers</td>
<td>TBD</td>
<td>Theoretical model under development</td>
<td></td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td><strong>Model (for metric development)</strong></td>
<td><strong>Model developed, applied, and published</strong></td>
<td><strong>Metrics to quantify dimension that compares infrastructures as initiators of damage to other infrastructure vs. targets of failures of other infrastructure</strong></td>
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<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>Rae Zimmerman</td>
<td>Directionality Metric</td>
<td>Model (for metric development)</td>
<td><strong>Risk and Economics Assessment, Risk Management</strong></td>
<td><strong>Risk and econ analys., utilities, emerg mgrs, policy makers</strong></td>
<td><strong>DHS (IAIP), national labs, researchers, utilities, government &amp; emergency mgmt agencies (NYC OEM)</strong></td>
<td>Model developed, applied, and published</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Rae Zimmerman, Carlos Restrepo</td>
<td>Cascading Effects Metrics</td>
<td>Model (for metric development)</td>
<td><strong>Risk Assessment; Economic Assessment; Risk Management</strong></td>
<td><strong>Risk and econ analys., utilities, emerg mgrs, policy makers</strong></td>
<td><strong>DHS (IAIP), nat labs, researchers, utilities, government &amp; emerg mgmt agencies</strong></td>
<td>Model developed, applied, and published</td>
<td>Metrics to quantify whether the subsequent infrastructure disruptions are greater or less than the initial infrastructure</td>
</tr>
<tr>
<td>Rae Zimmerman, Carlos Restrepo, Jeffrey Simonoff, Zvia Naphtali</td>
<td>Concentration Ratios for Infrastructure</td>
<td>Model</td>
<td><strong>Risk Assessment; Economic Assessment; Risk Management</strong></td>
<td><strong>Risk and econ analys., utilities, emerg mgrs, policy makers</strong></td>
<td><strong>DHS (IAIP), nat labs, researchers, utilities, government &amp; emerg mgmt agencies</strong></td>
<td>Model developed</td>
<td>Based on the location quotient model, ratios quantify concentration measures for infrastructure systems</td>
</tr>
<tr>
<td>Rae Zimmerman, Carlos Restrepo, Jeffrey Simonoff, Zvia Naphtali</td>
<td>Regression Estimation Toolkit</td>
<td>Models</td>
<td><strong>Risk Assessment; Economic Assessment; Risk Management</strong></td>
<td><strong>Risk and econ analys., utilities, emerg mgrs, policy makers</strong></td>
<td><strong>DHS (IAIP), nat labs, researchers, utilities, government &amp; emerg mgmt agencies</strong></td>
<td>Models developed and applied</td>
<td>Estimate prediction intervals for electricity outage duration and customer loss in different geographical locations and for different seasons.</td>
</tr>
<tr>
<td>Rae Zimmerman, Carlos Restrepo, Jeffrey Simonoff, Zvia Naphtali</td>
<td>Economic Accounting Toolkit</td>
<td>Models</td>
<td><strong>Risk Assessment; Economic Assessment; Risk Management</strong></td>
<td><strong>Economics analysts, risk managers, and policy makers</strong></td>
<td><strong>DHS, researchers</strong></td>
<td>Models developed and applied</td>
<td>Economic costs associated with a terrorist attack on the electricity grid: business losses, premature deaths and injuries and traffic congestion.</td>
</tr>
<tr>
<td>Rae Zimmerman, Carlos Restrepo, Jeffrey Simonoff, Zvia Naphtali</td>
<td>Infrastructure Location and Concentration</td>
<td>Databases</td>
<td><strong>Risk Assessment; Economic Assessment; Risk Management</strong></td>
<td><strong>Risk and econ analys., utilities, emerg mgrs, policy makers</strong></td>
<td><strong>DHS, U.S. DOT, U.S. DOE, researchers</strong></td>
<td>Many databases complete; others under construction</td>
<td>Location of facilities, capacity and usage of infrastructure, including transportation, energy</td>
</tr>
</tbody>
</table>

50
3.3 Collaborative Projects

CREATE has collaborated with several DHS and other government agencies as well as with industry. Past or ongoing collaborations are shown in Table 7. CREATE only engages in these collaborations, if they are mutually beneficial to all parties involved. To assure this, we have developed an approach, where initially no money changes hands, but where resources are made available by each partner, either in terms of funds or in terms of people participating in the collaboration. This approach assures that there is no “free” contribution by CREATE that is not also returned by some investments of the collaborating partners. Typically, the initial resource allocations by the collaborating institutions is small – perhaps in the range of $10,000 to $50,000.

If the collaboration turns out to be mutually beneficial, there are several ways to continue. One is to expand the scope of the collaboration to other centers of excellence and to request funds from the Integrated Network of Centers. Another way is to write joint proposals. A third way is to expand the funding by one of the partners and provide additional resources to CREATE to provide the support requested. CREATE has and is pursuing each of these ways of leveraging collaborative activities.
### Table 7. Collaborative Projects

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>INSTITUTION</th>
<th>CONTACT NAME</th>
<th>CREATE LEAD</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Homeland Security Units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MANPADS Decision Analysis</td>
<td>Countermeasures MANPADS Office</td>
<td>Kurt Willstaetter</td>
<td>von Winterfeldt</td>
<td>Completed</td>
</tr>
<tr>
<td>Performance Metrics for Infrastructure Protection</td>
<td>Office of Infrastructure Protection</td>
<td>Ralph Ley</td>
<td>von Winterfeldt</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Economic Assessment of Bioterrorism Events</td>
<td>Science &amp; Technology – NBACC</td>
<td>Stephen Bennett</td>
<td>Adam Rose</td>
<td>White Paper</td>
</tr>
<tr>
<td>Border Security Tabletop Exercise</td>
<td>Customs and Border Protection</td>
<td>Patrick Jones</td>
<td>Maya</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Risk Training for Immigration and Customs Inspectors</td>
<td>Immigration and Customs Enforcement</td>
<td>Joe Greene</td>
<td>von Winterfeldt</td>
<td>Started</td>
</tr>
<tr>
<td>State and Local Agencies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California Energy Commission</td>
<td>Electricity Security and Reliability</td>
<td>David Chambers</td>
<td>Maya/Chen</td>
<td>Contract in Process</td>
</tr>
<tr>
<td>Cost-Effectiveness of the Indoor Biowatch Program</td>
<td>California Department of Health Services</td>
<td>Raymond Neutra</td>
<td>O'Sullivan</td>
<td>Started</td>
</tr>
<tr>
<td>Risk-based Grant Allocation in California</td>
<td>California Office of Homeland Security</td>
<td>Erroll Southers</td>
<td>Kleinmuntz</td>
<td>Started</td>
</tr>
<tr>
<td>School Emergency Preparedness Proposal</td>
<td>South Bay School Districts</td>
<td>Deborah Chan</td>
<td>Maya</td>
<td>Not Funded</td>
</tr>
<tr>
<td>Port of Los Angeles Container Inspection Facility Proposal</td>
<td>A&amp;E Consortium</td>
<td>Pablo Valencia</td>
<td>Maya</td>
<td>Not Funded</td>
</tr>
<tr>
<td>Marina Del Rey Radiation Protection Proposal</td>
<td>LA County Sheriff's Department</td>
<td>Lt. Nelson</td>
<td>Maya</td>
<td>Under Review</td>
</tr>
<tr>
<td>Robocop Demonstration</td>
<td>LA Fire Department</td>
<td>Cpt. Ron Roemer</td>
<td>Tambe</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Integrated Network of Centers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Perception Survey</td>
<td>All Centers</td>
<td>INC Directors</td>
<td>von Winterfeldt</td>
<td>Started</td>
</tr>
<tr>
<td>Risk Analysis for Foot and Mouth Disease</td>
<td>Center for Foreign Animal and Zoonotic Disease</td>
<td>Neville Clarke</td>
<td>Bier</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Risk Analysis for Food Contamination</td>
<td>National Center for Food Protection and Defense</td>
<td>Frank Busta</td>
<td>Bier</td>
<td>Ongoing</td>
</tr>
</tbody>
</table>
4. MANAGEMENT

In its first year of operation, CREATE was managed by Randolph Hall (Principal Investigator and co-Director) and Detlof von Winterfeldt (co-Director). Dr. Hall was responsible for the general management of the center, educational programs and the engineering-focused research programs. Dr. von Winterfeldt was responsible for overseeing research in the risk analysis, economic analysis and threat analysis areas. On July 1, 2005 Dr. Hall was appointed Vice-Provost for Research Advancement of the University of Southern California and Dr. von Winterfeldt assumed the position of Principal Investigator and Director of CREATE. At the same time Isaac Maya, Ph.D., P.E., was hired as Director of Research to oversee the management of all CREATE research projects. The current organizational structure is shown in Figure 2.

The center is supported by three full-time staff, Sabrina Feeley (Business Manager), Kelly Gribben (Public Communications Manager) and Dr. Harry Bowman (GIS programmer). As a result of the increasing scope of the Education and Outreach activities, Ms. Gribben was recently offered the position of Director of Education and Outreach to manage these responsibilities. Her appointment is in the final stages of approval.

![Figure 2. Center Organization](image-url)

In addition, CREATE hired three post-doctoral researchers to conduct analyses in key areas. Dr. Terrence O’Sullivan (Ph.D. International Relations, USC) works in the area of risk assessment, and has specialized in aviation and biological threats. Dr. Onur Bakir (Ph.D. Industrial Engineering, Texas A&M) also works in risk assessment, and has specialized in border security. Dr. Luca Quadrifoglio (Ph.D. Operations Research, USC) joined the center as a specialist in optimization modeling and analysis of grant allocation systems.
With 24 ongoing projects we realize that some additional structure of thematic supervision and coordination is needed. To accomplish this, we have asked Dr. Adam Rose to coordinate all economic activities and projects. Dr. Vicki Bier has agreed to coordinate all risk analysis projects. We are still looking for a coordinator of the risk management activities, which are in transition. For now, Dr. Isaac Maya has taken on this responsibility.

With the arrival of Sabrina Feeley as business manager and Isaac Maya as research director, we have created several new financial and project management systems. On the financial side, we now have in place quarterly financial reports by projects and by general expenditure categories. On the project management side, we have an improved system of quarterly project progress reports and, with Dr. Maya’s supervision, a hands-on supervision of each of our projects and subcontracts.

The center management operates under the guidance of the Scientific and Government Advisory Committees (Table 8), and private sector companies. The Scientific Advisory Committee (SAC) consists of Ph.D. trained scientists working in homeland security related areas of research. It includes Dr. Ralph Keeney (Chairman, Duke), Dr. John Cummings (Sandia and DHS), Dr. Howard Kunreuther (University of Pennsylvania) and Dr. Jack Riley (RAND) as original members, Dr. Matthew Clark (DHS), with Dr. Mel Bernstein (DHS) as ex officio member. Two members were added in spring of 2005: Dr. Sherry Borener (NASA) and Dr. Robin Keller (UC Irvine). The SAC provides technical direction to the center and reviews the center’s products and plans.

Table 8. Scientific Advisory Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Ralph Keeney - Chairman</td>
<td>Duke University</td>
</tr>
<tr>
<td>Dr. John Cummings</td>
<td>Sandia Laboratories and DHS</td>
</tr>
<tr>
<td>Dr. Howard Kunreuther</td>
<td>University of Pennsylvania</td>
</tr>
<tr>
<td>Dr. Jack Riley</td>
<td>The RAND Corporation</td>
</tr>
<tr>
<td>Dr. Sherry Borener</td>
<td>NASA</td>
</tr>
<tr>
<td>Dr. Robin Keller</td>
<td>University of California, Irvine</td>
</tr>
<tr>
<td>Dr. Matthew Clark – ex officio</td>
<td>DHS</td>
</tr>
<tr>
<td>Dr. Mel Bernstein – ex officio</td>
<td>DHS</td>
</tr>
</tbody>
</table>
The Government Advisory Committees (GAC, Table 9) represents government and non-profit organizations (such as industry associations) and provides guidance on areas where research products are needed. The GAC includes sub-groups in the Western, Midwest and New York regions. CREATE is also working on the establishment of an Industry Advisory Committee (IAC). Over the two years, we had many contact with industry representatives interested in homeland security and we initiated a formal contact with an industry breakfast meeting in November of 2004. More recently, we announced the creation of a formal Industry Advisory Board with some modest membership fees.

USC is very supportive of CREATE. The Provost and the Deans of the Viterbi School of Engineering (VSOE) and of the School of Policy Planning and Development (SPPD) have made significant commitments to CREATE. In terms space commitments, CREATE occupies approximately 2,685 square feet in both VSOE and SPPD. CREATE’s headquarters are in VSOE’s Ronald Tutor Hall, which was build with the intent to serve interdisciplinary research. Both VSOE and SPPD support CREATE with operational funds, scholarships for eligible research assistants, and tuition a generous tuition remission match (CREATE pays 25% of tuition and the schools pay 75% for each CREATE research assistant).

<table>
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<tr>
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<td>California Energy Commission</td>
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<tr>
<td>George Cummings</td>
<td>Port of Los Angeles</td>
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<td>Floyd J. Davis</td>
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<tr>
<td>Tony Fainberg</td>
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<td>David Janssen</td>
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<td>Pat Jones</td>
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<td>Wynn Latta</td>
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<tr>
<td>Mark Leap</td>
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<tr>
<td>Bert Macesker</td>
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<td>Bernard K. Melekian</td>
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**Table 9b. Midwest Government Advisory Committee**

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<td>Brian Isle</td>
<td>Adventium Labs</td>
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<td>Susan King</td>
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<tr>
<td>Hal Sommer</td>
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<td>Jeffrey Western</td>
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**Table 9c. Eastern Government Advisory Committee**

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<td>Paul Bennett</td>
<td>Director of Security Planning, NYC Department of Environmental Protection Police</td>
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<tr>
<td>Gerry Bogacz</td>
<td>Planning Group Director, NY Metropolitan Planning Council</td>
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<tr>
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<td>David Davidowitz</td>
<td>Chief Engineer, Gas Operations, Consolidated Edison Company of NY</td>
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<tr>
<td>Patrick J. Devlin</td>
<td>Lieutenant, Counter-Terrorism Bureau, NYPD</td>
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<td>Michael Flynn</td>
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<td>Matt Koenig</td>
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<td>David Lipsky</td>
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<td>Al Lopez</td>
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<td>Jerome Lutin</td>
<td>Senior Director, Intermodal Planning and Capacity Analysis, NJ Transit</td>
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<td>MaryAnn Marrocolo</td>
<td>Director, Recovery and Mitigation, NYC Office of Emergency Management</td>
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<tr>
<td>William Morange</td>
<td>Deputy Executive Director, Director of Security, MTA- NYC Transit</td>
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<td>Mysore L. Nagaraja</td>
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<td>Thomas T. Newell</td>
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<td>Assistant Commissioner and Chief Financial Officer, NYC Department of Transportation</td>
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<td>Phil Pulaski</td>
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<td>Eugene Spruck</td>
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<td>Mike Valletta</td>
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<tr>
<td>Jill Woller</td>
<td>NYC Office of Management and Budget</td>
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5. EDUCATION

Since its original proposal, CREATE has made education a core component of its mission. CREATE’s proposing team felt strongly that a mix of research, education, and outreach was needed to make the center successful. This was based on the previous experience of Dr. Hall in developing the METRANS center and of Dr. von Winterfeldt in developing the Institute for Civic Enterprise at USC. Since universities are in the business of educating students, we afforded special attention to integrating an educational mission with the research mission of the new center to align the needs of the DHS, the center, and our incoming students.

5.1 Research Assistants

Most importantly, we believe that the main educational benefit from the university centers comes from training the next generation of experts in a broad range of homeland security issues. Local, regional, state, and federal agencies have a significant need for expertise in this area. CREATE’s initial focus was on the higher education levels – Ph.D.’s who could assume senior positions in academia, government, and industry. We were highly successful – recruiting more than 35 Ph.D. students into our projects. Most of these Ph.D. students are or will be writing Ph.D. theses on subjects related to terrorism and homeland security. In addition to the Ph.D. students, CREATE supports about 30 masters and 7 undergraduate students, bringing the total of CREATE research assistants to nearly 75 nation-wide in a variety of disciplines. Below (Table 10) is a list of students, their fields of study and their research areas. Many of our Ph.D. students are not yet at the point of deciding their thesis topics as they have only been with CREATE for one or two years. However, their current research interests are aligned with writing theses in the area of terrorism and other disasters.
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</table>
5.2 Masters and Certificate Programs

CREATE developed two new inter-disciplinary graduate programs—a Masters and a Certificate in System Safety and Security at the University of Southern California. These programs are available through the Viterbi School of Engineering’s Distance Education Network (DEN), permitting students to complete either program via the Web from any location in the United States.

The curriculum was developed to include a mix disciplines and skills that are desired in homeland security related careers. Both programs include a five-course core in Decision Analysis, Advanced Engineering Economics, Risk Analysis, Management of Government Funded Programs and Public Sector Economics. Students who continue on to the Masters degree take four elective courses, which follow tracks in such areas as environmental threats, infrastructure and information security. Two new courses, “Risk Analysis” and “Terrorism and Public Policy” were developed by CREATE to round out the program and ensure a breadth of knowledge appealing to homeland security and aligned with the center’s research. The risk analysis course covers the models and techniques of traditional risk analysis as applied to natural and engineered systems and draws lessons from these applications for terrorism risk analysis. The course on terrorism and public policy covers the nature of terrorism, the types of terrorist acts that threaten society, along with the possible public policy responses and their ramifications. Syllabi for the new courses are found in (see Appendix D).

The programs were approved in August of 2004 and are now available for enrollment—both appearing for the first time in the 2005/6 university course catalogue and officially launched in the Fall of 2005. The courses taught in this program are well attended, but the program still has few enrolled students. This is partly due to some restrictive entry requirements, and partly due to the lack of an aggressive recruitment program. We are now much more active in recruitment and we are reviewing the entry requirements. The recruitment program gains more exposure for the program via student events and special lectures, meetings with industry to market the program to working professionals, media relations, conference exhibits by DEN and potentially increased advertising. Brochures have been developed to enhance our efforts. (Figure 4).

Figure 4. Brochures for CREATE Educational Programs
5.3 Short Courses for Professional Education

USC has a first-rate aviation safety program that has operated for more than fifty years with more than 21,000 aviation professionals having completed coursework. This program is a close partner of CREATE and, as part of our collaboration, it was renamed the “Aviation Safety and Security Program” in 2005 and a new course in Aviation Security was developed in 2005. We are working on a second course in system safety. The program also undertook a comprehensive review to identify areas for expansion, particularly in the field of homeland security.

Based at Los Angeles International Airport (LAX), the program’s participating organizations include the FAA, NRSB, FBI, US Coast Guard, and all major airlines and manufacturers. The instructors are leading experts in the world and are active and current in their fields, including academic and practical leaders in Human Factors, acknowledged authorities in Risk Management & Risk Assessment, industry experts in security, former NTSB accident investigators, the president of Emergency & Disaster Management, and hazardous materials and legal instructors. The student profile is about 66 percent corporate and 34 percent government. (Brochure in Figure 4)

5.4 New Courses

Under CREATE support and guidance, 18 courses (Table 11), mostly graduate level, have been developed or modified to incorporate CREATE research and/or homeland security issues, teaching more than 500 students per year. Three new courses are marked with an asterisk and their syllabi can be found in Appendix D.

Table 11. CREATE Related Courses

<table>
<thead>
<tr>
<th>Instructor</th>
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<tr>
<td>1 Lester Lave</td>
<td>Carnegie Mellon</td>
<td>Business Government and Strategy</td>
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<tr>
<td>2 Zvia Naphtali</td>
<td>NYU</td>
<td>Advanced Geographic Information Systems &amp; Data Mgmt</td>
</tr>
<tr>
<td>3 Carlos Restrepo</td>
<td>NYU</td>
<td>Sustainable Cities: A Comparative Perspective</td>
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<tr>
<td>4 Rae Zimmerman</td>
<td>NYU</td>
<td>Environmental Impact Assessment: Processes &amp; Procedures</td>
</tr>
<tr>
<td>5 Rae Zimmerman</td>
<td>NYU</td>
<td>Urban Infrastructure and Environmental Services</td>
</tr>
<tr>
<td>6 Adam Rose</td>
<td>Penn State</td>
<td>Human Dimensions of Natural Hazards</td>
</tr>
<tr>
<td>7 Adam Rose</td>
<td>Penn State</td>
<td>Short Course on CGE Modeling Applied to Terrorism Impacts*</td>
</tr>
<tr>
<td>8 Erroll Southers</td>
<td>USC</td>
<td>Terrorism and Public Policy*</td>
</tr>
<tr>
<td>9 Detlof von Winterfeldt/Richard</td>
<td>USC</td>
<td>Risk Analysis*</td>
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</table>
CREATE has conducted internal seminars and training sessions, including a six-hour lecture series by Dr. Adam Rose on economic impact assessment models, held in the fall of 2005. We are now developing a similar series of lectures on decision and risk analysis in the form in a short (six hours) and long (three days with exercises) form. These sessions will be webcast and made available to other University Programs centers and to interested parties at the DHS. Guest lectures and seminars topics are aligned with the center’s research. Their durations range from three hours to three days. The following seminars have been offered by CREATE:

- Dr. Adam Rose, Penn State University, “Computable General Equilibrium Analysis Modeling Applied to Terrorism Impacts”
- Dr. Scott Farrow, GAO “The Economics of Homeland Security Expenditures: Foundational Expected Cost-Benefit Approaches”
- Dr. Bastien Soule, University of Caen (Normandy, France), “How to tackle risk within complex systems? A few theoretical reflections about danger and risk-generating systems”
- Dr. Alexia Brunet, “Grant Funding to State and Local Governments and Systematic Assessment of Vulnerability”

Most recently, CREATE has partnered with DHS to develop a tabletop exercise to examine the use of appropriate risk assessment tools to anticipate and thwart terrorist attacks on the U.S. The participants, including representatives from Immigrations and Customs
Enforcement, the U.S. Coast Guard, the Transportation Security Agency, DHS’ Office of Infrastructure Protection and Office of Policy, walk systematically from the point of origin to the point of attack through a hypothetical terrorist plot, to begin to identify suitable risk analysis tools that Customs Inspectors and Border Agents could use in anticipating, spotting and deterring terrorist attacks in the U.S. DHS anticipates that this exercise will serve as a testing ground for future exercises that could be expanded to include more participants and scenarios. Ultimately, this approach could form the basis for interactive “terrorism games”, which could be systematized through computer modeling or exercises involving experimental economics and interactive gaming using realistic scenarios and monetary rewards for successful “terrorist” actions and for successful countermeasures.

CREATE has also is in the process of developing an Immigration and Customs Enforcement Risk Analysis Course which would be a 2-3 day course in risk analysis aimed at the investigator and inspector level (GS 13-14).

5.6 DHS Scholars & Fellows Summer Internship Program

CREATE hosted four DHS Scholars and Fellows over a ten-week period in the summer of 2005. They included students from the University of Maryland, the University of Houston, Harvard University and the New Jersey Institute of Technology. Each was assigned to a CREATE advisor in different research areas including Risk, Emergency Response, Funding Allocations and Border Security. These students were exceptional and all of them produced very interesting and insightful research papers which tied into our current research and are available on our web site. This summer we are scheduled to host five DHS scholars, four at USC and one at NYU. (Figure 5)
5.7 Diversity

CREATE is committed to diversity and upholds it as a guiding principle in all of its programs. The center has made several efforts to generate diversity-specific programs as well. An important link between our research and diversity is the fact that terrorism risks economic impacts affect different communities in our society differently. In a non-terrorist disasters context this was demonstrated by the events surrounding hurricane Katrina. Our intention is not just to promote diversity in CREATE’s programs and collaborations, but to create diversity where it matters for research and education in homeland security: By identifying research topics that involve relevant minority issues (for example, evacuations after a terrorist attack), by engaging minority communities as participants and respondents in this research, and, most importantly, by involving minority researchers in collaborating with us on these projects.

CREATE supported the DHS minority research program in 2005 by hosting three faculty members and four students from minority serving institutions over a ten week period in the summer. The research projects included “ReDIReCT, Recovery and Disposal on Indian Reservations of Contaminated Tangibles” by Dr. Lloyd Mitchell and Brian Campbell, Elizabeth City State University, “The Evaluation of Emerging Technologies for Safeguarding Critical Surface Transportation Infrastructure; A Case Study of the Port of Charleston”, by Dr. Tom Whitney and L. Weldon Hammond II, of the James E. Clyburn University Transportation Center at South Carolina State University, and “Risk Modeling, Assessment, and Management of
Terrorism”, by James Ponnley, Kristen Young, and Latoya Clay of the Department of Mathematical Sciences at Clark Atlanta University. (Figure 5) We have reviewed six proposals for the 2006 summer, and plan on accepting three minority faculty-student teams at USC and one at NYU.

One of the teams in 2005 was very successful and we extended an invitation for the team to return in 2006 with funding from CREATE. CREATE has now initiated the first steps to create an official partnership with Elizabeth State University, an HBCU in North Carolina, as a result. We have actively searched for faculty members at Historically Black Colleges and Universities (HBCUs) and at Hispanic Serving Universities (HSIs) to find faculty members that match the research interests at CREATE. Recruitment is ongoing.

CREATE also established a relationship with the Thomas Rivera Policy Institute (TRPI) at USC, a nationally recognized Hispanic think tank. With joint funding from TRPI and CREATE, we have studied issues related to the implementation of NAFTA agreements at the Mexican border.

In addition, we have developed a minority-serving high school homeland security education and outreach program. This is a cooperative program between CREATE and the University of Southern California’s Center for Active Learning in International Studies (CAILIS). It began on an ad-hoc basis in 2004, and as designed by Terry O’Sullivan, has centered around case-based learning modules with domestic and global homeland security themes, aimed at local minority-serving Los Angeles high school students (juniors and seniors) and their teachers. All high schools have had 90 percent or above minority populations. Themes developed thus far have focused on biological security, especially threats, vulnerabilities and consequences of catastrophic infectious disease outbreaks either terrorist-caused or naturally occurring. Current plans are to use $5000 of CREATE funding for FY06 to expand involvement of teachers and students; broaden involvement to other CREATE researchers; broaden the curriculum to include more general and/or specific homeland security themes; and to develop web-based materials that encourage high school classroom-based and independent learning environments.

CREATE also participates in a minority-serving high school internships program by hosting high school students interested in homeland security for one semester. This is a unique learning experience for the student to learn about homeland security and related career opportunities as well as university research.

5.8 Internship Programs

Through USC and its partners, CREATE has been placing students into internships in organizations that benefit homeland security. Some of these include:

- The Aerospace Corporation
- BAE Systems
- The Boeing Company
- City of Beverly Hills Fire Department
5.9 Innovation in Education

To adapt to technological advancements and the current learning style of today’s students, CREATE has been dedicated to the development of innovative educational vehicles in homeland security related topics. CREATE is currently engaged in a “serious gaming” project with an experienced game lab at USC to develop a serious training game for emergency responders. We will also deliver our upcoming seminars on a web basis to increase their accessibility as educational modules to a broad audience. In addition, our masters and certificate programs are offered on-line through USC’s Distance Education Center.

CREATE has collaborated with Gamepipe Laboratories of USC to develop the serious training game, Firescope: Incident Commander. The project engaged students from the USC Viterbi School of Engineering to develop a complete game prototype. Firescope is a real-time cognitive thinking serious game with the objective of minimizing the hazards of nature, crime and terrorism by marshalling emergency forces, using real fire, police and medical data and strategies to safely reign in disasters. Firescope is designed to use entertainment to enhance the instruction of emergency responders, especially those training as incident commanders, in the wide range of disasters they may encounter in the field. The incident commander is responsible for the overall management of a hazard scene and must make quick decisions to manage resources and information efficiently. The gaming project team worked closely with CREATE and CREATE government contacts to accurately portray the incident commander role. One of our chief goals was that the gameplay and aesthetics of Firescope reinforce the real-world concepts in emergency situations. The game is based on CREATE's research and development of an agent-based simulation tool for disaster rescue.
6. OUTREACH

CREATE developed an active outreach program consisting of events, external presentations, development of communications materials and vehicles, public relations through the media, and outreach to external organizations.

6.1 Workshops and Events

CREATE has organized nine conferences and workshops and another large-scale conference is scheduled for May 17, 2006. Our conferences were designed to elicit a wide range of views, as represented by the more than 60 organizations that presented at the events. All events have been well-attended and useful, based on evaluations gathered at their completion. Completed events are described below, the participating organizations are listed in Table 12, and the agendas are included in Appendix E as accompanying tables.

Economics Symposium. In August, 2004 CREATE held a two-day symposium (Table E-1 of Appendix E) that brought together leading academic scholars concerned with the economic impacts of terrorism. The purpose was to review the state-of-the-art of economic modeling in this area. The book, “The Economic Impacts of Terrorist Attacks” was published in 2005, resulting from the papers presented at the symposium. (Figure 6)

![Figure 6. Book Cover](image)

Conference on Reducing the Risks and Consequences of Terrorism. The conference was held in November 2004 and showcased the research activities of the center and university (Table E-2 of Appendix E). We also invited speakers from other research centers, including Lawrence Livermore National Laboratory, the Naval Postgraduate School and the RAND Corporation. The conference was attended by 250 individuals, with a mix of participants from the private sector, government and research institutions.
**Terrorism Risk Analysis Workshop.** Following a similar format as the economics workshop, a terrorism risk analysis workshop was held in January, 2005 (Table E-3 of Appendix E). 15 presentations on advances in risk analysis to model and analyze terrorist events were given. The papers resulting from this conference will be published in the journal *Risk Analysis* in 2006.

**Port Security Workshop.** CREATE was a sponsor of the Maritime Cargo Security Conference in March, 2005 (Table E-4 of Appendix E). The conference featured discussions by industry, government and academic experts on the nature of risk to our logistic network, the economic and political costs of preparing for and responding to assaults on the network, and developing a contingency plan to respond to incidents in the region. CREATE co-directors and researchers presented on subjects including the risks from maritime cargo movement and economic and political costs of prevention and response.

**National Symposium on the Future of Terrorism Risk Insurance (I & II)** In June 2005, CREATE co-sponsored with the RAND Corporation a conference designed to bring together researchers, corporate leaders and policymakers to frame and analyze the ongoing policy debates related to the Terrorism Risk Insurance Act (TRIA), terrorism risk management and insurance (Table E-5 of Appendix E). Due to significant interest, a second was held in Washington, D.C. in October 2005.

**Economic Costs and Consequences of Terrorist Attacks.** In August 2005, CREATE held its second two-day economics conference that brought together leading academic scholars concerned with the economic impacts of terrorism (Table E-6 of Appendix E). The purpose was to review the state-of-the-art of economic modeling in this area. Each presenter prepared a paper, which will be published in an edited book in 2006.

**US/UK Building Partnerships for Homeland Security Solutions.** The objective of this event was to promote and facilitate US/UK collaboration for the development of new technologies, software and products for homeland security (Table E-7 of Appendix E). This was a unique opportunity for US companies and researchers to exchange expertise and forge partnerships with their British counterparts. Leading academic and industry experts conducted panel discussions in the areas of Risk and Economic Assessment of Terrorist Threats, Biometrics for Personal Identification, Sensing Systems and Sensor Networks, and Information Management and Data Mining.

**CIA Regional Intelligence Conference.** CREATE partnered with the CIA’s Center for the Study of Intelligence for the first of a series of regionally-focused conferences on intelligence studies (Table E-8 of Appendix E). The conference brought together scholars and veteran intelligence officers to discuss topics of critical importance to understanding today’s national intelligence community through a program of panels and presentations. One panel focused on Homeland Security, Intelligence and Risk Analysis.

**The Risks and Economic Impacts of Terrorism (scheduled for May 17, 2006).** This is one of the largest conferences organized by CREATE to showcase the center and its research (Table E-9 of Appendix E). The aim of this conference is to provide homeland security
leaders an opportunity to gain critical knowledge about the risks and economic impacts of terrorism. Through panel discussions and presentations, we will engage representatives from federal and local agencies, industry leaders, and academia to focus on improving homeland security through risk-based decision making. We will be discussing on risk based resource allocation, economic impacts and responses to terrorism, and risk management strategies.

**Table 12. Participating Organizations at CREATE Events**

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<th>Organization Name</th>
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<td>Texas Southern University</td>
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<td>Cornell University</td>
<td>Texas Southern University</td>
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<td>Former Insurance Commissioner of New York</td>
<td>The Communications Institute</td>
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<td>Information Sciences Institute</td>
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<tr>
<td>Lawrence Livermore National Laboratory</td>
<td>U.S. Department of the Interior</td>
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6.2 Presentations by Center at Events

As part of our outreach efforts, center researchers are encouraged to present their research at professional conferences and events. A partial listing of presentations is provided in Table 13. Of these 188, 120 were research conference presentations, and 68 were outreach events.

Table 13. Presentations

<table>
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<th>CONFERENCES</th>
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<td><strong>Bakir, N. Onur</strong></td>
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<td><strong>Bier, Vicki / University of Wisconsin-Madison</strong></td>
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Dessouky, Maged / Ordóñez, Fernando


Hall, Randolph


Information Sciences Institute


Larson, R. C. / Structured Decisions Corporation


39) Larson, R.C., “Models for Designing Response Plans to Catastrophic Events,” INFORMS, Denver, CO,


O'Sullivan, Terrence

44) O'Sullivan, T., “Comparative Risk Analysis & threat Adaptability: Civil Aviation and Biological Terrorism,” Center for Risk and Economic Analysis of Terrorism Events (CREATE) Homeland Security Conference, University of Southern California, Los Angeles, California, November 18, 2005.


Richardson, Harry / Gordon, Peter / Moore II, James


Richardson, H., Gordon, P., Moore II, J., “The Costs of a Terrorist Attack on Terminal Island at the Twin
Ports of Los Angeles-Long Beach,” Public Policy Institute of California Symposium on Protecting the

Terrorist Attack on the Ports of Los Angeles/Long Beach,” Public Policy Institute of California, San

Richardson, H., Gordon, P., Moore II, J., CREATE Conference on Reducing the Costs and
Consequences of Terrorism, USC, Los Angeles, CA, November 18, 2004.

Richardson, H., Gordon, P., Moore II, J., “The Role of Supply Chains in Industrial Engineering”
(Keynote presentation), The International Conference on Computers and Industrial Engineering, San

Richardson, H., Gordon, P., Moore II, J., Organizers, Center for Risk and Economic Analysis of
Terrorism Events (CREATE) Symposium on the Economic Cost and Consequences of a Terrorist

of Los Angeles-Long Beach,” Center for Risk and Economic Analysis of Terrorism Events (CREATE)
Symposium on the Economic Cost and Consequences of a Terrorist Attack, USC, Los Angeles, CA,

Power System of Los Angeles: Customer Resilience to a Total Blackout,” presented at the North

Rose, A., “Tracing Infrastructure Interdependence through Economic Interdependence,” Workshop on
Resilient Infrastructure, Taupo, NZ, August, 2005.

Tambe, M.

for Human Omnipresence to Coordinate Agent Teams: The Future of Disaster Response,” Poster
Presentation in Proceedings of the Fourth International Joint Conference on Autonomous Agents and

Tambe, M., “Virtual Reality Simulations for Disaster Rescue”, US-Israel Science and Technology
Foundation Symposium on Applications of Virtual Reality, Israel, 2005.

Schurr, N., “The DEFACTO System: Training Tool for Incident Commanders,” The Seventeenth
Innovative Applications of Artificial Intelligence Conference (IAAI), 2005.

Tambe, M., “Demonstration,” Fourth International Joint Conference on Autonomous Agents and

Tambe, M., “Challenge Problems in Artificial Intelligence for Homeland Security” (Panel Discussion),

Tambe, M., “Multi-agent Simulations for Disaster Rescue” (by Nathan Schurr), AAAI Spring

Tambe, M., “Multi-agent Simulations for Disaster Rescue,” Virtual Reality Symposium, Israel via
Teleconference, March 7, 2005.

Tambe, M., “Demonstration of Our Initial Disaster Rescue Simulation,” Columbia University
International Joint Conference on Autonomous Agents and Multi-agent Systems, New York, NY,

von Winterfeldt, D.

von Winterfeldt, D. "Risk and Economic Analysis of Terrorism Events." Risk Symposium 06, Santa Fe,
New Mexico, March 21, 2006.

von Winterfeldt, D., "Terrorism Risk Assessment," Presentation at the CIA Regional Intelligence


Zimmerman, Rae / New York University


Zimmerman, R., “Global Climate Change Impacts on Coastal Infrastructure Services,” U.S. Climate Change Science Program Workshop: Climate Science in Support of Decisionmaking, Washington, DC,
November 14, 2005.


**OUTREACH EVENTS**

**Bier, Vicki / University of Wisconsin-Madison**

117) Bier, V., “CREATE” to the Southwest Chapter of the Wisconsin Society of Professional Engineers, Wisconsin.


119) Bier, V., “Game-Theoretic Methods in Counter-Terrorism and Security” to the Sauk Institute for Leadership, Sauk County, Wisconsin.

120) Bier, V., “Game-Theoretic Methods in Counter-Terrorism and Security” at Towson University (in a class on Information Technology Infrastructure), and at the Homeland Security Institute.


**Dessouky, Maged / Ordóñez, Fernando**


**Hall, Randolph**


**Information Sciences Institute**


**Larson, R.C. / Structured Decisions Corporation**


National Fire Protection Association, Quincy, Massachusetts, November 2004.


Maya, Isaac

McLeod, Dennis

O’Sullivan, Terrence

Richardson, Harry / Gordon, Peter / Moore II, James

Rose, Adam / Pennsylvania State University

Smith, V. Kerry / Research Triangle Institute

Smith, V. K., "Adjusting to Disasters," Texas A & M University, March 6, 2006.


von Winterfeldt, Detlof


6.3 Outreach to External Organizations

CREATE meets with external organizations, in addition to groups within DHS, on a regular basis at a director level. These meetings are often exploratory collaboration meetings as well as general outreach to our potential user community. Here is a partial listing:

Table 14. External Organizations (partial listing)

<table>
<thead>
<tr>
<th>ABS Consulting</th>
<th>Los Angeles County Public Health Dept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archangel (DHS funded)</td>
<td>Los Angeles Police and Fire Departments</td>
</tr>
<tr>
<td>Argonne National Laboratory</td>
<td>Monterey Institute</td>
</tr>
<tr>
<td>BAE Systems</td>
<td>National Institute of Justice</td>
</tr>
<tr>
<td>Batelle</td>
<td>Northrop Grumman</td>
</tr>
<tr>
<td>BENS-Business Execs for Nat’l Security</td>
<td>PNL</td>
</tr>
<tr>
<td>The Boeing Company</td>
<td>Port of Long Beach</td>
</tr>
<tr>
<td>British Consulate-General</td>
<td>Port of Los Angeles</td>
</tr>
<tr>
<td>California Office of Homeland Security</td>
<td>Public Policy Institute of California</td>
</tr>
<tr>
<td>The Center for Asymmetric Warfare</td>
<td>Raytheon Company</td>
</tr>
<tr>
<td>Department of Health Services</td>
<td>RAND</td>
</tr>
<tr>
<td>DOD—Northern Command</td>
<td>SAIC</td>
</tr>
<tr>
<td>General Dynamics</td>
<td>Sandia National Laboratories</td>
</tr>
<tr>
<td>Israeli Consulate</td>
<td>Southern California Association of</td>
</tr>
</tbody>
</table>
6.4 Center Publicity/Marketing

CREATE has produced a variety of communications tools to educate the public about our mission, our research and the DHS university centers program.

Our website (www.usc.edu/create, Figure 7) is continuously updated and receives more than 200 hits per day. We are regularly adding information and improving it to keep it relevant and current. While it is a major vehicle for center news and events, it is also a complete description of our activities and our mission. The site includes summaries of our research projects, research products, biographies of our researchers, as well as information about our educational programs and advisory committees.
Other communications materials for successful outreach have been developed, including a brochure that gives an overview of the center and has recently been updated (Figure 8). Educational brochures have also been produced to highlight CREATE’s new Masters program through the Distance Education Network and another for the Aviation Safety & Security Program. Marketing pieces for distribution to industry partners have also been produced.

![CREATE Brochure](image)

**Figure 7. Website Homepage**

An official CREATE logo and identity program was also developed and launched in summer 2005.

An electronic newsletter, containing news from the center and news relating to homeland security, is circulated on a monthly basis. We continuously enhanced it with more articles, links and homeland security information.

Through our outreach activities, we have developed a large database of relevant contacts. This database currently exceeds 1000 and is utilized as a means for consistent communications nation-wide.

Media relations for the center have been successful with more than 100 positive articles or interviews completed. We have developed a media list targeting reporters and publications specializing in homeland security, science, education and business, as well as specific research areas, and continue to cultivate relationships with members of the local and national media in press, television and radio. We have developed key messages for the center and have disseminated those to our lead researchers to be used when they address the media. Media training was given at the director level and we are considering supplementing this with training for other team members. A library of transcripts and articles written about the center and its researchers has been compiled and is updated regularly. Below is a partial list of media coverage.
6.5 DHS Outreach

We have developed many contacts in the operational units of the DHS, partly by us seeking out clients and users of our case study methodologies and results, and partly by DHS staff seeking our advice. Secretary Chertoff’s emphasis on risk based decision making has created substantial interest in the agency in collaborations with CREATE. Examples of clients of our case studies are the Countermeasure MANPADS office, the Office for Border Control and Protection, and the Office of Infrastructure Protection. We also providing support for the National Biodefense Analysis and Countermeasures Center and Immigrations and Customs Enforcement. All of these contacts have evolved in collaborative projects that are jointly supported by the DHS and by CREATE.

6.6 Other Outreach

In addition to working closely with clients at the DHS, we have clients in regional and local agencies. These include the California Energy Commission, the California Department of Health and Human Services, the California Office of Homeland Security, the Los Angeles Mayor’s Office, and the Los Angeles County’s Sheriff’s Department and the Los Angeles Fire Department. In addition, we communicate with the local and regional homeland security, law enforcement, and emergency response community through our regional government advisory
committees. We communicate with industry through frequent one-on-one meetings. We have had over 100 industry contacts since the inception of CREATE and about 40 collaboration meetings with industry partners. Some of these contacts have resulted in joint proposals.
7. INTEGRATION

Integration across projects within the center is achieved through the matrix structure of CREATE’s research. As shown in Table 16, CREATE’s research projects relate to each other through their contribution within the research framework. Within each research category, research projects are carefully coordinated to allow investigator flexibility to innovative basic research while minimizing duplication of effort. For example in risk assessment, the game-theoretic research projects of Bier and Hall explore complementary approaches to analyzing the indeterminate probabilities of terrorist actions based on their observations of site defenses. In the economic assessment area, the input-output models of Gordon, Richardson and Moore are complemented with the computable general equilibrium model of Rose.

The three case studies are, by their very nature, interdisciplinary. For example, to develop the Year 1 case study dirty bomb model required the expertise of risk analysts, decision analysts, counterintelligence experts, blast and plume modelers, radiological health effects experts, decontamination experts, behavioral researchers with knowledge about evacuation behavior, and economists. In the Year 2 resource allocation case study, CREATE is integrating approaches applicable at the site and building level (Bier and Bank), infrastructure level (Zimmerman, et al.), city level (Bier), and state level (Kleinmuntz and QuadriFoglio). Not all the expertise required for a case study is obtained within CREATE. CREATE has engaged outside expertise, such as the national laboratories, which have been extremely helpful in providing models and information. CREATE has also occasionally used special outside expertise, for example, in radiological detection devices and in counterterrorism. One of the strengths of the center approach is the ability to create mixes of expertise to work on a common problem efficiently.

Many of our projects integrate products from multiple institutions within CREATE. For example, NYU, UW-M, USC, Cornell, and CMU faculty all worked on the Year 1 electricity case study. In Year 2, the resource allocation case study is integrating input from UW-M, NYU, and USC. Two ongoing projects involve CREATE and other DHS centers of excellence. UW-M and USC researchers work with the Foreign Animal and Zoonotic Disease Center on the risk analysis aspects of foot and mouth disease. UW-M and the National Center for Food Protection and Defense collaborate on risk analysis as well. We also recently invited START to participate in our border security case study tabletop exercise with the DHS Customs and Border Protection.

The Integrated Network of Centers (INC) is our main vehicle for inter-center collaborations. The seven center directors meet regularly by phone and bi-annually in person to discuss joint activities, gaps in research, education needs, etc. The most recent INC meeting was hosted by CREATE. At the last INC meeting in January of 2006, several themes for cross-center collaborations were identified and leads were assigned to these themes. CREATE is leading two collaborative efforts, one on risk perceptions of terrorism and one on economic impacts, and has representation in the other five, with three representatives from USC, one from UW-M, and one from Strategic Decisions Corporation.

CREATE also actively participates in the DHS Science and Technology Action Team (STAT) activity. This activity integrates participants across all the DHS national laboratories.
and Centers of Excellence. CREATE has closely collaborated with the other CoEs in identifying the special needs of CoEs relative to national laboratories in compiling our responses to DHS requests for information. The result has been the development of a customized template that accommodates the research and developmental nature of university projects while still resulting in a template suitable for DHS’ needs in emergency response.

CREATE integrates its research with other DHS needs on an ongoing basis. Our DHS collaborations were described in the applied relevance section of this summary. Through these collaborations as well as through the collaborations with national laboratories, CREATE has developed an effective, informal network of collaborators that is steadily growing. We routinely meet with Boeing on their airline security analysis initiative and the impact of MANPADS on the airline industry. Our industry collaborations have resulted in three proposals, of which one (that included Boeing input) is pending and the other two were not funded (one of which was led by an industry consortium that included Boeing and RAND). We have renewed our efforts to create closer ties to industry by creating an industry advisory committee, and have met individually with many additional companies, such as The Aerospace Corporation, Northrop Grumman, General Dynamics, GE, etc. An informal meeting of the industry advisory committee was held in 2005, and a more formal meeting is planned for the summer of 2006.

In addition to hosting faculty from minority serving institutions and their students during the summers of 2005 and 2006, we also have integrated by collaboration with Elizabeth City State University, a historically black university in North Carolina. Lloyd Mitchell, a faculty member at Elizabeth City State, will continue research that he began as a summer visitor in 2005 on risk of terrorism to Indian casinos, integrating into the bioterrorism case study. This work is partially funded by the DHS, partially by CREATE. We are continually searching for qualified faculty in risk analysis and economics in minority serving institutions to expand these collaborations. This summer, we expect to expand our involvement by engaging four teams of summer faculty and students from minority institutions.
Table 16. Integration among Research Areas and with Case Studies

<table>
<thead>
<tr>
<th>Modeling and Analysis Areas</th>
<th>Basic Research</th>
<th>Models, Tools, and Databases</th>
<th>Case Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Assessment</td>
<td></td>
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</tr>
<tr>
<td>1. “Terrorism and US Foreign Direct Investment, and Counterterrorism Policy Evaluation”</td>
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<tr>
<td>2. “Decision Analysis to Counter Terrorism”</td>
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<tr>
<td>3. “Innovations in Risk and Economic Modeling of Counter-Terrorism”</td>
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<td>4. “Strategic Decision-Making in the Presence of Adversaries”</td>
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<tr>
<td>5. “Network Reliability Models”</td>
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<tr>
<td>6. “Risk Assessment and Analysis for Improved Planning for Foreign Animal &amp; Zoonotic Disease Defense”</td>
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<td>7. “Resource Allocation in the Context of Bioterrorism”</td>
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<tr>
<td>8. “Portfolio Allocation in Building Security”</td>
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<tr>
<td>9. “Risk-Based Allocation of Resources to Counterterrorism”</td>
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<tr>
<td>10. “Risk Analysts’ Workbench (RAW)”</td>
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<td>x</td>
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<tr>
<td>11. “Geographic Information Systems (GIS) Support”</td>
<td>x</td>
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<tr>
<td>Economic Assessment</td>
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<tr>
<td>12. “Economic Impact Modeling and Analysis”</td>
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<tr>
<td>13. “Economic Impact Modeling and Analysis with Computable General Equilibrium Models”</td>
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<tr>
<td>15. “Assuring Essential Services during a Bioterrorism Attack”</td>
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</tr>
<tr>
<td>16. “Risk Perception and Behavioral Economics”</td>
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<tr>
<td>Risk Management</td>
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<td></td>
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<tr>
<td>17. “Emergency Response Modeling”</td>
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<td>x</td>
<td></td>
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<tr>
<td>18. “Emergency Supply Planning”</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>19. “Agent Based Simulation for Disaster Rescue”</td>
<td>x</td>
<td>x</td>
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<tr>
<td>20. “Security in Multiagent Systems by Policy Randomization”</td>
<td>x</td>
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<tr>
<td>21. “Resource Allocation Based on Critical Infrastructure”</td>
<td>x</td>
<td>x</td>
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</tr>
<tr>
<td>22. “Critical Infrastructure for Border Security”</td>
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</tbody>
</table>
8. THE FUTURE OF CREATE

8.1 A Vision and Mission for CREATE

CREATE aspires to be the leading national center for research and education in analyzing and managing the risks of terrorism other disasters. CREATE will be known for its unique capabilities for developing and applying an integrated methodology for risk and economic modeling and analysis. CREATE also will be known for its unique mix of fundamental and applied research that has relevance for high-level decision making and policy setting. CREATE will also be the lead institution for educating future leaders in addressing issues related to terrorism and other disasters.

Key aspects of this vision are:

- Distinction as a national leader - we believe that the terrorism risk field will soon be filled with many competitors – some with significant experience and others who are new to the field - and that CREATE will need to distinguish itself by developing the next generation of models and tools; we are already recognized as a national leader in modeling and analyzing the economic impacts, but in this field as well, we want to be at the front of modeling and research related to economic impacts of terrorism. We believe that advances in behavioral and experimental economics are needed to accomplish this mission.

- Analysis and management of risk - we want to be known for both risk analysis and management; this implies that our mission will evolve with an increasing emphasis on policy, decision making, and implementation in all areas of risk management, including prevention, protection, and response and recovery. To accomplish this, we will enhance CREATE’s expertise and capabilities in decision and policy analysis.

- Include non-terrorism disasters – it seems natural to expand the scope of CREATE to include natural and engineered risk and disasters. We will add studies of natural disasters using hurricanes as a start, but also considering earthquakes and floods. We will also add studies of disasters resulting from accidents in engineered systems. Many of these studies can be funded from sources outside of the DHS. In five years, we should have a fifty-fifty split between terrorism and non-terrorism risks and also non-terrorism research funds that match the funds provided by the DHS for terrorism research.

- Integration of risk and economics – to truly integrate the risk and economic aspects, we will evolve our research framework and methodologies to assure that the risk management cycle addresses the interconnections and linkages between analysis and management.

- Mix of fundamental and applied research with relevance for decision making – CREATE’s research should be relevant for decision making and policy setting, the difference between fundamental and applied research becomes blurred. However, we clearly see some research projects for which the applied payoff may take much longer (years) and involve substantial risks vs. some research projects that have shorter term (months to a year) payoff with relatively low risk and we will continue to pursue both types of projects.
• National leader in education - our emphasis is on producing the future leaders that can deal effectively with the complex problems in terrorism and other disasters, either as future researchers and academics, or as industry and government leaders. In our educational mission, we will emphasize diversity, keeping in mind that many solutions to problems involving disaster affect many different communities in different ways and that future leaders have to have a clear awareness of this.

8.2 Expanded Research Scope

In the first two years, we have pursued two main approaches to risk assessment: Traditional probabilistic risk assessment (PRA) and game theory. We have encountered some limitations of applying traditional PRA methods, but we also found some areas that are easier to execute with PRA. As a result, we plan to push the PRA frontier further along in the terrorism area, especially regarding the use of expert judgment, secondary probability distributions and sequential dynamic decision analyses. Game theory proved to be conceptually very useful and provided interesting results. In the future, we plan to expand our game theoretic work to include dynamic and stochastic games.

For economic impact analysis, we have developed and used spatially disaggregated input-output models and CGE models. We also have expertise in econometrics, contingent valuation and cost-benefit analysis. In the future, we plan to conduct more research on behavioral aspects of terrorism. These include models of risk perception, behavioral responses to terrorism both ex ante and ex post, experimental economics, and dynamic games. We recently conducted a workshop with a group of CREATE and outside economists to define the research themes in economics for the next five years of the center. This group identified the following high-priority research topics:

• Understanding and measuring resilience in response to disasters
• Behavioral adjustments – ex ante and ex post – in response to terrorism
• Economic models of terrorists’ objectives and capabilities
• Improvements of economic impact models
• Bundling public goods to reduce terrorism risks
• Models of detection and indicators of terrorism events
• Public values and preferences for public and private measures to reduce terrorism risks

In the summer of 2006, we will ask for project proposals in these areas and pursue the most promising ones. In addition, we see great opportunities in the areas of experimental economics and games.

In the long term, we see a merger of risk and economic analysis, not by piecing the two approaches together as in Figure 1, but by truly integration them in a dynamic, adaptive, stochastic modeling environment. Decision analysis, stochastic and dynamic games, and experimental economics will be used to integrate the risk and economics areas.
8.3 A Mix of Applications, Applied Research, and Fundamental Research

The case study model has worked well for CREATE – both internally by providing integration among research teams and externally by linking CREATE to clients at the DHS and elsewhere. We plan to continue this approach during the renewal period. In addition, we plan to add a short term response component to CREATE’s mission, including responses to DHS and other client’s needs that can be met with off-the-shelf tools in one to several months. We also would like to engage our partners at the operational units at the DHS in longer term collaboration (one year or more) to help them address significant problems.

8.4 Management Directions

We believe that we have a very stable and successful management team in place and do not see any need to make major changes in the near future. The implementation of a new layer of leadership in risk assessment, economic assessment, and risk management will be tested in year three of CREATE. This new leadership structure will be combined with an executive committee consisting of the director, the three lead faculty, and the directors of research, outreach, and education. This configuration will be considered as an experiment in the third year and evaluated at the end of the period.

8.5 Education

We have been very successful in recruiting and supporting research assistants, moderately successful in creating new courses and educational programs, but not very successful in recruiting students for the new programs and in engaging minority serving institutions. Our efforts in year 3 and beyond will be on these two less successful areas. We will also make efforts to attract more U.S. students.

8.6 Outreach, Communication, and Transitioning

CREATE had a very quick start in its outreach and communications efforts. Since research products require some time to be disseminated and transferred to the user community, we do not yet have a strong record of transitioning our results to clients and users. However, we have many models, tools, and databases under development and we expect that the RAW platform will be our main vehicle to transferring CREATE models, tools, and basic knowledge to a road range of clients and users.

8.7 Integration

We believe that our intra-center and inter-center integration has been very successful. In particular, with CREATE taking the lead in at least two INC efforts, and with two ongoing inter-center collaborations, we fit into the interdisciplinary, multi-institutional model to which the INC aspired. We also were successful from the start in linking with the national laboratories as a result of several CREATE researcher’s prior connections with the labs. We had a bit of a slow start with connections to the DHS operational units, but with our approach of horizontal networking, we have now managed to engage several DHS offices and we will continue to build
on this network. Admittedly, we have only been moderately successful in establishing collaborations with minority serving institutions. We will work harder to expand these collaborations and to establish research projects that are supported by and serve research questions involving minorities.
Appendix B

Synopses of Year 1 Projects

1. Arming Aviation Security Professionals with the Latest Tools & Technologies

**Background:** In 1952, USC established the first Aviation Safety Program at a major research university. Since then the program has gained a highly respected reputation nationally and internationally, with more than 21,000 aviation professionals from over 65 nations having completed its courses. The program was originally developed by a project team of faculty from three disciplinary areas: engineering, management and psychology. The courses they developed integrated appropriate subject matter from these areas into a comprehensive systems approach to safety.

**Goal:** Reduce Vulnerability. To provide U.S government agencies, major air carriers and aircraft manufacturers with the best professional training in aviation safety available anywhere in order to counter terrorist threats and improve our homeland security.

**Approach:** There are 15 different courses available, with approximately 40 total sessions scheduled each year. Courses are scheduled consecutively to permit out-of-state and international students to stay for a period to complete a sequence of courses or an entire certificate program. The Certificate Program in Aviation Safety, which requires an individual to complete a series of courses, has been completed by over 1000 students.

Continuing Education Units (CEU’s) are available upon request. One CEU is awarded for every 10 hours of instruction.

Individual courses are designed to provide the student with expertise in a particular subject area. While each course is constructed as a whole and taught independently of the others, those interested in preparing for a full-time career in aviation safety should consider a program of courses that provides broad knowledge. We award the University of Southern California’s *Aviation Safety Certificate* to those successfully completing the required program. It certifies completion of training in several multidisciplinary areas including Aviation Safety Management, Accident Investigation, Human Factors and Technology.

**Outcome:** The Aviation Safety Program will play a prominent role in the Center’s education effort, contributing professional programs in system safety and risk-based economic analysis.

**Deliverables:** A new course was created in Aviation Safety and taught in the spring of 2005. It was taught again in the fall of 2005. Aviation Safety program was renamed Aviation Safety and
Security. As a result of a comprehensive program review, additional security related courses will be introduced in the next year.

**Project Lead:** Michael Barr, 310-342-1345, barr@usc.edu
2. Critical Infrastructure

**Background:** The nation’s critical infrastructure has a key life-saving and quality of life role, makes an enormous contribution to the Gross Domestic Product, and has assets estimated to be worth several trillions of dollars. Infrastructure systems are vulnerable to disruption by virtue of their large physical distribution networks and centralized production systems. Catastrophic terrorist attacks on infrastructure have occurred globally. Given these threats and the potential for cascading effects of attacks on the nation’s infrastructure exacerbated by interdependencies, the U.S. government has placed a high priority on their security. Many models are used to estimate risks and impacts of infrastructure on the economy, and inputs to and validation are needed based on actual events. Consequences of terrorism for infrastructure are often similar to those that occur from natural hazards, accidents, or sabotage. Thus, experiences from other events can help evaluate infrastructure vulnerabilities in terrorist situations, enhancing our ability to respond to impacts of terrorist attacks more effectively.

**Goal:** Reduce Vulnerability To assess the threat, vulnerability, risk and impacts of potential terrorist attacks on critical infrastructure and effects of infrastructure impairments on human life and the economy from actual events as a basis for investments to reduce impacts in the event of such attacks.

**Approach:** An extensive case database of infrastructure disruptions is developed from incident and accident reporting systems, web-based resources, news media, and other sources. Codes are assigned to event location, cause, interdependencies impacting other systems, and economic and social costs. Indicators are designed to allow decision-makers to capture the direction and magnitude of various effects including interdependencies and the impact of interventions to focus risk reduction efforts. Indicators are applied to the data to identify common vulnerabilities across events and conditions. Infrastructure areas emphasize energy, and include transportation, water, and communications. Vulnerabilities and risk reduction findings are then used as inputs to risk and economic modeling to prioritize alternative courses of action.

**Outcome:** The general conclusions of this work are that:
- Databases of non-terrorist outages and statistical models provide the basis for a tool for identifying vulnerable grid scenarios and developing terrorism scenarios for risk and consequence assessment
- Three components are viable economic cost estimators - premature deaths, business loss, and transportation disruptions. Statistically based models provide an important tool for inputs into the business loss component of economic cost estimates for electric power outages. Simpler equations are also tools to estimate the cost of premature deaths and transportation congestion.
- Applying these tools, however, indicates that civil unrest, another attack taking advantage of the outage, or severe cascading effects would have to accompany a 24-hour outage to produce costs equivalent to a major catastrophe, such as September 11.

**Deliverables:** Numerous publications and presentations as listed in the body of the Final Report.

**Project Lead:** Rae Zimmerman, New York University-Wagner Graduate School of Public Service, (212) 998-7432, rae.zimmerman@nyu.edu
3. Risk Analysis – Dirty Bomb Analysis

**Background:** The threat of a radiological dispersal device (RDD or “dirty bomb”) has been recognized for several years, since this type of device is much easier to manufacture and deliver than an actual nuclear explosive weapon. The consequences of a dirty bomb attack could be devastating though, especially if critical infrastructure elements like ports are affected.

**Goal:** Prevent Terrorist Attacks The project will develop and apply a comprehensive methodology to assess the risks of a dirty bomb attack on the Los Angeles/Long Beach harbors. It also will identify cost-effective countermeasures to prevent such an attack.

**Approach:** The methodology consists of four tasks:

1. Risk analysis of scenarios for a dirty bomb attack in ports – this task includes the creation and prioritization of plausible scenarios and of conducting a detailed project risk analysis to determine the probability of success for selected scenarios;
2. Consequence assessment of the direct and indirect impacts of a dirty bomb attack, including modeling of the radioactive plume and their health effects;
3. Emergency response modeling, including an exploratory analysis of using agent based models for on-the-scene responses to a dirty bomb explosion
4. Economic impact assessment, including and input-output analysis of the economic consequences of a long-term shut-down of the harbors.

In addition, we explored possible countermeasures (radiological detection devices, screening of cargo containers, etc.) and assessed their costs and benefits.

**Outcome:** This work analyzes possible terrorist attacks on the ports of Los Angeles and Long Beach using a radiological dispersal device (RDD, also known as a “dirty bomb”) to shut down port operations and cause substantial economic and psychological impacts. Using risk and economic analysis methods, the paper begins by identifying the most likely dirty bomb attack scenarios in terms of sources of radiological material, delivery modes and detonation sites. A project risk analysis is developed for selected scenarios to identify the tasks terrorists need to perform to carry out this project and to determine the probability of the project’s success. The consequences of a successful attack are described in terms of human health effects and economic losses. The findings show that the chances of a successful dirty bomb attack are lower than expected and the health consequences of even a major attack are relatively small. However, the economic consequences from a shutdown of the harbors could result in significant losses. The implications of detecting, intercepting and countering a dirty bomb attack are discussed.


**Project Lead:** Detlof von Winterfeldt, USC, SPPD, 213-740-4012, detlof@usc.edu.
4. Economic Impact Modeling and Analysis

**Background:** The benefits of alternate mitigation and protection strategies are the costs avoided. To calculate these, losses for various scenarios, including the baseline, must be estimated. Because losses have a geographic dimension, economic modeling approaches must be spatial. Our group is interested in developing the models and data to estimate economic impacts in spatial detail with the objective of supporting resource allocation decisions. We have done this at the sub-metropolitan level for the greater Los Angeles area, estimating impacts for over 3,000 traffic analysis zones (TAZs, generally similar in size to census tracts) as well as at the sub-national level (in a separate model) for the 50 states and the District of Columbia.

**Goal:** Minimize Damage (i) To develop and test spatial economic models able to assess employment and income losses at fine levels of spatial detail within metro areas. (ii) To develop and test similar models that assess impact transmissions between the fifty states (and the District of Columbia).

**Approach:** Updated the prototype Southern California Planning Model (SCPM), incorporating better data and solution algorithms so that the economic consequences of various terrorist attack scenarios can be evaluated; the results would be for the Los Angeles metropolitan area and specific to 300+ local jurisdictions – and all of the links of the local highway network and possibly the rail network; elaborate SCPM to include human casualties; extended SCPM to include endogenously determined rail freight shipments (only highway freight shipments are currently endogenous). Developed the National Economic Interstate Model (NIEMO), an interstate trade model for the 50 U.S. states (and the District of Columbia) to trace the economic consequences of a terrorist attack in any one on all the other states of the union.

**Outcome:** Recommendations on modeling approaches to be used across the U.S.; recommendations on policy responses to various terrorist attack scenarios. For example, a variety of port security efforts can be justified given the size and scope of the losses that we have estimated. The same goes for efforts to boost security at major theme parks. Our estimates of commercial air system losses are large when compared to the cost of MANPADS countermeasures, suggesting that many of them are cost-effective. We note, however, that the principal cost of MANPADS countermeasures will likely consist of maintenance and replacement, not installation. Our group also organized symposia where economists interested in the analysis of the terror threat presented their work, exchanged ideas, and compare competing assumptions and approaches. The first was held on August of 2004 and resulted in a proceedings volume that will be available in December 2005. The second CREATE economics symposium was held in August of 2005 and the proceedings have been edited and will be sent to the publisher early next month. The third symposium is scheduled for August of 2006 and will include economists and well as risk analysts. All will present papers that address the Katrina disaster and its aftereffects.

**Deliverables:** Numerous publications and reports detailed in the body of the Final Report.

**Project Lead:** Peter Gordon, 213-740-1467, pgordon@usc.edu. James E. Moore, II, 213-740-0595, jmoore@usc.edu, Harry W. Richardson, USC, 213-740-3954, hrichard@usc.edu.
5. Risk Models of Emergency Response

**Background:** Analyzing risk models often involves a determination of the expected values of functions of multiple random variables. As it is often not possible to explicitly compute these values, simulation is often applied. Because there are usually many such quantities, depending on various risk assumptions, it is important that the simulations be done in such a manner as to quickly give accurate estimates of the desired quantities. One approach that has often been applied is to try to use successive simulation runs to obtain identically distributed unbiased run estimators that are not independent but rather are negatively correlated. The value of this is that it results in an unbiased estimator (the average of the estimates from all the runs) that has a smaller variance than would the average of identically distributed run estimators that are also independent. We show how to obtain identically distributed but negatively correlated estimators from successive simulation runs when computing the expected value of a function that is monotone in some of its coordinates.

**Goal:** Minimize Damage To develop probabilistic models that can be utilized to evaluate the effectiveness of current emergency response systems.

**Approach:** Expanded use of antithetic variables, and Schur functions of permutations.

**Outcome:** Our research has resulted in improved simulation estimation procedures in problems where one needs to compute the expected value of a random subset, or the expected value of a function of random variables when that function is monotone in some of its coordinates. Our research has obtained conditions under which each new subset should be randomly chosen from among those elements not in any of the previously chosen subsets. It is based on new concept of a Schur function of a permutation, and shows that using non-overlapping subsets is efficient when the items can be ordered so that the function is monotone function in the indices of the elements of its argument.


**Project Lead:** Sheldon Ross, University of Southern California, 213-740-4893, smross@usc.edu
6. Emergency Response

**Background:** Despite our best efforts to reduce risks, catastrophic events can occur that overwhelm local first emergency responders. Such an event could be a terrorist attack or an act of nature. Local police, fire and EMS services will be on the scene first and find themselves unable to provide the magnitude and mixture of services needed. Theirs is a holding and rescue operation pending the arrival of regional second responders and perhaps third level federal responders. The 2nd and 3rd levels of responders constitute a mixture of well-trained professionals and others less skilled but very willing to help (e.g., uninjured civilians). The types and numbers of second and third level responders who are needed is a function of the type of major event. The responding specialists should be trained in any one or more of the following: HAZMAT removal, bomb squads, crime scene analysis, infrastructure repair, medical triage, mobile communications, etc. Key to the success of a coordinated response is up-front planning. No one wants to contemplate another terrible event such as 9/11/01. But without adequate response planning, the numbers of serious injuries and lives lost after the event may be greater than the numbers injured and lost instantaneously as a direct consequence of the event. Planning can save lives, oftentimes many lives.

**Goal:** Minimize Damage  The goal is to develop a deep understanding of the realities of emergency response to catastrophic events and to develop a set of quantitatively based tools to assist planners in designing informed emergency response plans for such disasters.

**Approach:** SDC’s approach is to develop a family of analytical planning models that incorporate personnel and equipment resource allocation during the three-wave response to a major unexpected event. The models will be modular and linked, designed to allow alternative scenarios to be examined. The models will allow the users to examine the consequences of alternatives related to the following factors: numbers and initial locations of personnel, by type; transportation options available to each level of responder; estimates of numbers of seriously injured and deceased, by time since event occurred; level of usability of needed technologies under alternative assumptions of infrastructure damage and other factors as determined by interviews with national leaders representing each level of responder. Through use of analytical modeling techniques, the team will also be able to solve complex problems in emergency response without resorting to time-consuming simulation techniques, thus making it simpler to plan, evaluate and estimate consequences from desktop computers.

**Outcome:** The key result product of SDC’s CREATE-sponsored research efforts is the emergency response planning model under development. Utilizing a map interface, which can depict the geography of any United States municipality, the model’s user ‘generates a disaster’ by specifying its type, location and time of occurrence, and severity. The model determines which areas of the municipality have been impacted and cords them off, effectively ‘destroying’ the patrol cars and ambulances located in the affected areas when the disaster occurred. Next, the user specifies how many of the surviving response units are to be deployed to the affected areas and the model optimally chooses which of the surviving units to send. Additionally, a ‘locate-allocate algorithm’ determines the optimal locations of those units surviving the disaster but not dispatched to the affected areas while a ‘matching algorithm’ optimally decides which particular units to deploy to each of those locations.

**Deliverables:** Numerous reports listed in the body of the Final Report"; *Updated Desktop Hypercube™ Design Document*; prototype software.

**Project Lead:** Professor Richard C. Larson, Structured Decisions Corporation, 1105 Washington Street, West Newton, Massachusetts 02465, 617-244-1662 rclarson@mit.edu
7. Emergency Supply Planning

**Background:** A key ingredient in an effective response to an emergency is the prompt availability of the necessary supplies at the emergency sites. For example, to address out-breaks of infectious diseases, the Federal government's Strategic National Stockpile contains 300 million doses of smallpox vaccines and enough antibiotic to treat 20 million people for anthrax. In the event of an emergency, these vaccines would be delivered in push packages of emergency supplies to the Emergency Staging Area (ESA). Timely delivery and disbursement of adequate supplies at ESAs pose major logistical challenges, more so in high-density urban regions like Southern California.

**Goal:** Minimize Damage To develop a family of planning models that incorporate personnel and equipment resource allocation and the distribution of inventoried items, such as vaccines, in the context of a three-wave response to a major unexpected event

**Approach:** There exist research both on emergency system dynamics (such as the propagation of diseases and performance of vaccination strategies) and on distributions systems in non-emergency scenarios. However to date, this research has not been integrated in the form of distribution systems for emergency situations. We address this gap in the research community by developing emergency response planning models for the distribution of inventoried items. Our research specifically focuses on addressing the following interrelated questions in the context of an emergency:

- Where to store locally supplies for emergencies, and what shall be the supply levels at each location?
- What is the best strategy to disburse supplies once an emergency has occurred?

At the heart of both questions we address there is a transportation network to distribute the inventoried supplies. The question of where to set the storage facilities can be translated to a facility location problem within this supply network. The problem of disbursement of supplies can be posed as a vehicle routing problem on this network.

The developed models were tested on hypothetical large-scale emergency scenarios. The facility location and vehicle routing problems are respectively formulated and solved. It is shown that the proposed models obtain solutions that provide better coverage than solutions generated by traditional models in the literature. We have made progress toward integrating these models in a GIS planning tool

**Outcome:** The benefits of modeling and solving the facility location and vehicle routing problems are two-fold. First, from a planning perspective, the models and solutions can aid planners to optimally determine the facility locations and vehicle routes and thus maximize the efficiency and effectiveness of the medical supply chain system as a whole. Second, these plans can become well tested operating policies, which, during an emergency, could be integrated with real-time information to generate the most suitable operation procedures for the specific emergency that has occurred.


**Project Lead:** Maged M. Dessouky, USC, (213) 740-4891, maged@usc.edu
8. Countering the Threat of Weapon Attacks on Commercial Aircraft

**Background:** Surface-air missiles, as well as some conventional weapons, pose a serious threat to commercial aircraft, due to the large number of weapons in circulation and their effectiveness in attacking aircraft. While no such attack has occurred on U.S. soil, an unsuccessful attack occurred in Kenya in 2002, and several successful attacks are believed to have occurred in Africa in the past. To address this threat, the Department of Homeland Security has invested in prototypes and system engineering for aircraft-mounted counter-missile technology, but this is one of many approaches to countering the threat, and the full consequences of weapon threats have not been fully explored.

**Goal:** Prevent Terrorist Attacks To complete a risk and economic analysis of external weapon threats (i.e., weapons fired from outside aircraft) to commercial aviation, and to use this analysis to recommend cost-effective solutions for improving aviation safety.

**Approach:** Weapon threats will be evaluated from the perspective of risks, consequences, response and economic impact, including the following tasks:

- Risk analysis will develop potential threat scenarios, defined by location, weapon technology, target and timing. Risk analysis will survey the preparedness of governmental agencies and private organizations for responding to threats.
- Consequence assessment will model the impact of explosions on aircraft as well as the ground impact of an attacked aircraft. Consequence assessment will also analyze the impacts on the airspace in the minutes and hours immediately following an attack.
- Emergency response will simulate the deployment and management of response personnel should an aircraft crash as the result of a weapon attack.
- Economic analysis will be used to estimate the immediate economic consequences, as well as the subsequent effects on the airline industry in the event of a threat or a successful attack. We will also evaluate the economic consequences.

Following this analysis we will investigate the effectiveness of various counter-measures, including both technological and non-technological solutions.

**Outcome:** Recommendations on investments to improve aviation security in the presence of weapon threats combined with assessments of their effectiveness.


**Project Lead:** Randolph Hall, University of Southern California, 213-740-4894, rwhall@usc.edu
9. Risk Analysis

**Background:** Risk analysis has become a common tool for estimating the probabilities of natural hazards and industrial accidents, such as nuclear power plant accidents, earthquakes, dam failures, and hurricanes. Risk analysis is therefore a promising tool for estimating the risks of terrorism attacks. However, there are several challenges in applying risk analysis to terrorism. First, the threat is driven by intelligent and adaptable adversaries that can observe and respond to our defensive measures. Second, threats can involve an extremely wide variety of events. Finally, attacks can be aided by insiders with knowledge of the most vulnerable parts of a system. Therefore, advances are needed to improve the applicability of risk-analysis tools to terrorism risks.

**Goal:** Prevent Terrorist Attacks To develop enhanced risk-analysis methods suitable for the analysis of risks from terrorism, and use these methods in support of threat assessments.

**Approach:** We will begin by developing a master logic diagram or structured set of scenarios of possible threats (initiating events). Experts will then review and modify the master logic diagram, and evaluate the probabilities and severities of the threats. Threats will then be ranked according to weighted combinations of probability and severity, so that the most likely threats and those with the most severe consequences will receive high priorities. We will also develop dynamic resource allocation methods incorporating game theory principles. In particular, we will develop risk-management models that explicitly take into account possible terrorist motivations, levels of knowledge, and constraints, and explore how the nature of optimal defensive investments depends on those assumed terrorist characteristics, and on the characteristics of the system to be protected (e.g., series/parallel system structures). The result will be a family of decision tools for improving security as cost-effectively as possible, and qualitative guidelines that can be used when the quantitative tools are impractical to implement. These tools will then be applied to threat assessments for ports, commercial aircraft, and critical infrastructure (electricity). Following these analyses, we will investigate the effectiveness of possible counter-measures, including both technological and non-technological solutions.

**Outcomes:** A set of models and procedures to estimate the risks of various terrorism attacks, a systematic approach for prioritizing terrorist threats, models for identifying optimal risk management measures, and guidelines for risk management based on the results of those models.


**Project Lead:** Vicki Bier, University of Wisconsin-Madison, 608-262-2064, bier@engr.wisc.edu
10. SAAS: Simulation-Based Analysis of Aviation Security

**Background:** The SAAS project is developing a simulation-based decision support tool to enable airspace security personnel to rapidly respond to terrorist or other aviation emergencies on a regional or nation-wide basis. Currently, there is no system that can evaluate the range of risks and economic losses that accompany a major emergency rerouting of commercial aircraft. In response to a terrorist situation, the SAAS tool can rapidly assess the cost of possible responses, and then recommend rerouting of airborne aircraft to appropriate airports. SAAS builds on prior USC research in planning, visualization, very large scale simulation, and models assessing aviation risk and economic cost.

**Goal:** Reduce Vulnerability  An end-to-end system that can simulate a nationwide model of airborne commercial aircraft, and plan optimal responses to simulated emergencies.

**Approach:** The heart of the system is a high-performance discrete event model simulator capable of tracking the real and simulated behavior of all aircraft en route at any given time within the continental United States. Simulator state is initialized by tapping historical aviation data, or in a real situation, importing aviation information directly from a major airport (e.g., LAX) to plot the position, heading and destination of all in-service commercial aircraft. When an emergency is introduced into the model scenario, the simulator will enable aircraft to exhibit independent behavior that reflects responses appropriate to the emergency. Decisions of where to route aircraft will be optimized based on a global cost-benefit (utility) model. The complexity of the model will grow to include weather, and passengers, hotels and other support facilities, airport traffic control centers (which may become disabled), possible cyber attacks on aircraft systems or communication systems, and other entities determined to be relevant to DHS preferences and needs. The system will execute on processor clusters that can be scaled to support increasing numbers of entities, and to search increasing numbers of possible simulation outcomes.

**Outcome:** The SAAS simulator infrastructure makes paper risk models “come alive” (and vice-versa). It provides a repeatable platform to allow modelers fine tune parameters and to allow responders to adjust their response strategies accordingly. The Simulator enables learning/training in advance of actual crises. This practice aids the human responders to assimilate the doctrine so that they react properly in time of an emergency. Moreover, repeated practices may help the responders to discover new and improved response to a given situation.


**Project Lead:** Ke-Thia Yao, University of Southern California/Information Sciences Institute, 310.448.8297, kyao@isi.edu.
11. Agent Based Simulations for Disaster Rescue

**Background:** In the shadow of large-scale national and international terrorist incidents, it is critical to provide first responders and rescue personnel with tools and techniques that would enable them to evaluate response readiness and tactics, evaluate inter-agency coordination and improve training and decision making capability. The recent hurricanes that have hit the gulf coast of the US have served to reaffirm the need for emergency response agencies to be better prepared for large scale disasters. Both natural and manmade (terrorism) disasters are growing in scale, however the response to these incidents remain managed by a single person, namely the incident commander. The incident commander must monitor and direct the entire event while maintaining complete responsibility. Because of this, incident commanders must start to be trained to handle these large scale events and assist in the coordination of the team. We are developing such tools in the form of simulations of intelligent software agents that simulate first responder tactics, decisions and behaviors in urban areas, at the city or even the block level.

**Goal:** Minimize Damage The goal of this project is to develop the DEFACTO system (Demonstrating Effective Flexible Agent Coordination of Teams via Omnipresence), which is a multiagent based tool for training incident commanders for large scale disasters man made or natural). The focus of our research is in building tools for training and tactics evaluation for first responders. These tools are based on teams of software agents as they deploy in a disaster created by a large-scale terrorist attack. Such teams include agents that simulate fire engines, ambulances, and police cars, all of which plan and act autonomously in a simulation environment. Via their interactions with these software agents, humans can evaluate tactics and realize the consequences of key decisions, as they respond in the event of such disasters, thus in essence achieving training goals. With DEFACTO, our objective is to both enable the human to have a clear idea of the team’s state and improve agent-human team performance.

**Approach:**
- Disasters are modeled by extending the Robocup Rescue simulation environment.  
- This simulation is connected to the Machinetta teamwork proxy architecture to guide behaviors. Each Robocup Rescue emergency responder (Police car, fire engine, ambulance) has an intelligent agent (Proxy) on the Machinetta side associated with it. Responders communicate with their agents via individual proxy interfaces.
- On top of the simulation environment, we display the virtual world in a high-resolution 3d map, to allow for a human to quickly recognize the current situation
- Overall team behavior is supervised by human experts, who provide advice to the team of agents regarding whether to pick or drop their current tasks via this 3D view.

**Outcome:** We have created an agent-based simulation environment of first responders to a terrorist attack, for training human experts and for tactics evaluation. Our system combines a high fidelity simulator, a redesigned human interface, and a multiagent team driving all of the behaviors. Training incident commanders provides a dynamic scenario in which decisions must be made correctly and quickly because human safety is at risk. When using DEFACTO, incident commanders have the opportunity to see the disaster and the coordination/resource constraints unfold so that they can be better prepared when commanding over an actual disaster. We have also published numerous papers listed in the body of the Final Report.

**Deliverables:** “The DEFACTO System: Training Tool for Incident Commanders”; prototype software.

**Project Lead:** Milind Tambe, USC, 213-740-6447, tambe@usc.edu
12. Distribution of Transnational Terrorism among Countries

Background: Post-9/11 actions to augment security in wealthy nations can have unintended negative consequences by inducing terrorists to stage their attacks in countries less able to afford widespread defensive measures. Thus, the new emphasis on homeland security in the United States and throughout the European Union (EU) may displace terrorist attacks to softer venues where people and property from prime-target countries (e.g., the United States) are attacked abroad. This transference of attacks may be income or geographically founded. When transference is income based, attacks may be displaced from high-income countries to low-income countries as the former deploys enhanced security measures that make attacks more difficult and costly for terrorists to accomplish. If the transference is geographically founded, then the displacement may be from a rich region (e.g., Europe) to a poorer region (e.g., the Middle East or Eurasia). A geographical shift may also be motivated by the ability of terrorists to establish a support system, especially for religious fundamentalist terrorists.

Goal: Prevent Terrorist Attacks Using event-based data for transnational terrorist incidents during 1968-2003, we identify the change in the distribution of such incidents following 9/11. The primary goal is to empirically evaluate whether terrorists have shifted their venue based on target countries’ income or location, given security upgrades in rich countries following 9/11.

Approach: We apply time-series methods to ascertain changes in the pattern of terrorist events over time. Our methods account for other key influences (i.e., the rise of fundamentalist-based terrorists in 1979 and the end to the Cold War in 1991). We develop two different partitions of countries based on income. The first uses the World Bank designation of high-income countries, middle-income countries, and low-income countries based on measured levels of per-capita gross national income, while the second distinguishes just two income classes – the 32 highest per-capita income countries and all others. We rely on the six geographical regions, given in the Department of State Patterns of Global Terrorism, to partition countries geographically. We analyze four different time series of transnational terrorist events: all incidents; incidents with casualties; incidents with a US target; and casualty incidents with a US target. Possible transference patterns following 9/11 are examined for each series for the alternative income partitions of countries and the location partition.

Outcome: An understanding of the influence of income and geography on the changing distribution of transnational terrorism to help direct the allocation of antiterrorist resources. Our analysis can show whether homeland security displaces attacks against Americans to foreign venues. If this is the case, the analysis identifies the dangerous locations and nations, where the United States might need to assist other countries or regions in addressing terrorism.

Deliverable: "Distribution of Transnational Terrorism among Countries by Income Classes and Geography After 9/11"

Project Lead: Todd Sandler, University of Southern California, 213-740-9695, tsandler@usc.edu.
13. Probabilistic Representation of the Threat and Consequences of Weapon Attacks on Commercial Aircraft

**Background:** The Department of Homeland Security has determined that external weapon threats due to surface-air missiles, as well as some conventional weapons, pose a serious threat to commercial aircraft. Many factors that are highly random in nature (such as the type of missile or weapon used, the proximity and orientation of the warhead/weapon detonation with respect to the aircraft, the structural characteristics of the aircraft, and the fragility level of the damaged aircraft components, such as fuel tank, engine, etc), influence the level of hazard to which a target aircraft is subjected to, as well as the subsequent damage of an exploding aircraft debris on the ground below.

**Goal:** Reduce Vulnerability  Develop and apply computational tools based on probabilistic structural dynamics approaches to represent the threat as well as the consequences of external weapon threats to aircraft, so that the resulting format can be utilized in an assessment of the economic effects of such threats.

**Approach:** The following tasks were implemented as part of this activity:
- Three generic types of aircraft were represented in a three-dimensional mathematical model (using state-of-the-art finite element software packages), in which all of the critical aircraft subsystems are fairly accurately represented.
- A risk analysis procedure was developed for potential threat scenarios, defined by location of the explosion, weapon technology, target structural component, and timing.
- Using Monte-Carlo simulation approaches, an extensive number of potential threat and aircraft combination scenarios was performed to establish probabilistic “fragility curves” that represent the uncertainties inherent in the aircraft threat exposure as well as the structural damage consequences.
- Based on the previous tasks, probabilistic “hazard contour maps” were created to assess and display the debris ground impact effects, should an aircraft be destroyed in flight.
- The aircraft failure probability and its debris effects on the ground were supplied to collaborating researchers to assess the economic damage from the scenario threats.

**Outcome:** This effort yielded a general methodology for developing and implementing a modular software package for quantifying and propagating the uncertainties associated with the specification of a postulated terrorist attack. Among the main random parameters considered are: the aircraft location and orientation, the aircraft flight path trajectory, the aircraft characteristics, the probability of a weapons-induced crash, and the random distribution of explosion debris, etc. This framework can be used to develop quantitative (probabilistic) measures of the consequences of typical MANPADS attacks on typical civilian aircraft.


**Project Lead** Sami Masri, University of Southern California, 213-740-0602, masri@usc.edu
14. Vulnerability Assessment and Security Analysis of Electric Power System

**Background:** Previous work under National Science Foundation Multidisciplinary Center for Earthquake Engineering Research, 47 scenarios of major earthquakes in the Southern California region were developed that exert a major impact on the reliability and security of the electric grid, governed by WECC (Western Electricity Coordinating Council). The study analyzed the effects of such a major disaster on the grid in the Los Angeles basin and in particular, the effects on both the Los Angeles Department of Water and Power (LADWP) and Southern California Edison Co. (SCE) service territories. These earthquake scenarios were developed based on probability assessments by geologists, and generally do not coincide with scenarios that would exert the most severe impact on the electric power system. Terrorist attacks, on the other hand, are pre-planned and are calculated to exert the most severe detrimental effects both on the system and on the various infrastructures that the system serves. Therefore, entirely different scenarios will have to be developed.

**Goal:** Reduce Vulnerability. The prior work will be extended to determine the most vulnerable scenarios for an interconnected electric power grid failure precipitated by a terrorist attack, by using the WECC system as a prototype. The goal is to evaluate the impact of terrorism on the electrical grid concentrating on worst-case scenarios, so as to be able to anticipate the most severe outcomes of such potential terrorist attacks. The analysis of the impact will be focused in the Southern California region.

**Approach:** We gathered all the system information for the WECC grid to carry out the analysis. We prepared software packages to simulate system power flow and perform reliability analysis. We employed the IPFLOW programs developed by EPRI for our use. We developed several scenarios for the power grid by first concentrating on major transmission systems and substations.

**Outcome:** Several scenarios were simulated to examine the effects of a terrorist-induced outage in the Los Angeles basin. Several examples include:

1. If receiving station Q is attacked in the Los Angeles harbor area, a loss of 216 Megawatts (MW) will disable the whole Los Angeles harbor area, but would not affect the rest of the city.
2. If receiving station N is attacked, a loss of 190MW will result in the complete shut down of the Los Angeles International Airport, severely disrupting air traffic, for hours.

Other combinations of attacks disrupt power to large percentages of specific areas of the city. These interpretations represent a very preliminary analysis of the impact of terrorist attacks on the power system security in the city of Los Angeles. These analyses demonstrate clearly that even a minor attack on any number of critical power system in fractures can inflict potential serious damage to the city of Los Angeles.

**Project Lead:** T.C. Cheng, University of Southern California, Electrical Engineering Department, 213-740-4712, tcheng@usc.edu
15. Analyzing Terrorist Threats to the Economy Through Computable General Equilibrium Analysis

**Background** The September 11 terrorist attacks were intended to inflict severe harm to both the psyche and economy of the United States. The attacks clearly demonstrated that economic impacts are not limited to the destruction of the initial target itself but extend to other economic sectors and to other geographic areas through what has traditionally been called “multiplier” effects.

**Goal:** Reduce Vulnerability The purpose of this research proposal is to evaluate the potential of state-of-the-art economic impact modeling approach, computable general equilibrium (CGE) analysis, to analyze and estimate the economic effects of terrorism and its mitigation. The primary objective of this research is to estimate the direct and indirect economic impacts of an extended electric power outage caused by a terrorist attack in a major U.S. city--Los Angeles, California.

**Approach:** CGE is a multi-market simulation model based on the simultaneous optimizing behavior of individual consumers and firms, subject to economic account balance and resource constraints. It incorporates the best features of several other types of economic impact models, such as input-output analysis, and adds several additional capabilities. For example, the CGE model divides the economy into sectors, so that one can more clearly distinguish potential targets. It captures not only features of interdependence through production requirements for goods and services but also through the role of prices and markets, so that it can analyze the full range of economic impacts. It adds a behavioral dimension, so that we can analyze how individual decision-makers protect themselves before and respond after a terrorist incident. The CGE model provides a basis for analysis at the microeconomic (individual), mesoeconomic (industry and individual), and macroeconomic (overall economy) levels. It is also capable of being applied at a range of geographic resolutions including metropolitan areas, states, regions, countries, and the global economy.

**Outcome:** The work serves as a proof of concept of the application of a computable general disequilibrium model to estimate the business interruption impacts of the terrorist attack on the electricity power system serving Los Angeles County. The model has been especially designed to incorporate engineering and spatial aspects of the electric power system in the context of the regional economy, to reflect the several types of disequilibria that an electric power disruption will bring about, to include the various inherent and adaptive resilience responses at the individual, market, and economy-wide levels, and to capture both partial and general equilibrium effects. The simulation of a two-week total electricity blackout in LA County amounts to a business interruption loss of $20.5 billion without any resilience adjustment and $2.8 billion with the inclusion of several types of resilience, most prominently the rescheduling (recapture) of production after electric service is restored. The results indicate that inherent aspects of the electricity-economy relationship (e.g., interfuel substitution) and adaptive behavioral responses (e.g., conservation, on-site electricity generation) can reduce the potential disruption impacts by 86 percent.


**Project Lead:** Adam Z. Rose, Penn State University, azr1@psu.edu
16. Risk Analysts’ Work Bench (RAW)

**Background:** Formal quantitative risk analysis has been an important tool for defending against mechanical system failure and project failure or delay. Many software packages have been constructed for aiding in analyzing project or mechanical system risk. Risk analysis is now being used for assessing the risks of terrorist attack. Terrorism is similar to mechanical systems in that, given an event, a chain of dependencies and consequences can be examined to estimate the likely outcomes and the value of mitigation efforts can studied. Unlike traditional mechanical system failure or project risk, terrorism is the result of intelligent attackers, making decisions about whether to attack, what to attack, when and how. Terrorists, unlike natural or mechanical threats, can observe some or all of the mitigation efforts of the defender and possibly adjust to them. Existing risk analysis packages generally lack a framework for capturing adversarial behavior. The estimation of consequences given a terrorist event may involve complex models of damage, human, physical, and economic. While some risk analysis software incorporates such models, the packages are frequently closed to adding models without significant programming. The lack of a common framework also prevents effective collaborations among researchers locally and across the nation.

**Goal:** Prevent Terrorist Attacks, Reduce Vulnerability  The goal of this work is to develop a Windows based software modeling system -- called the “Risk Analysts’ Workbench (RAW)” -- that provides modeling and analysis capabilities for the risk analyst and decision-maker. RAW provides a mechanism for extracting data from external sources, building libraries of data for internal use and linking models to support other modeling steps. RAW guides the risk analyst through the steps of threat and counter-measure characterization, probability estimation, outcome definition, and scenario creation. It also provides tools to the decision-maker for rating outcomes of threats, effectiveness of counter-measures, and prioritizing investments.

**Approach:** Development of the package was initiated, and we are currently refining and updating the code’s requirements and design specifications. We will interview subject matter experts (SMEs) to determine how the do business. We will then compile lists of tools, data, and supporting documentation used in risk assessments, lists of problems with current approaches, and lists of desired features/functions SMEs would like to see if RAW. We are currently developing the initial prototype, and will soon establish a server populated with existing CREATE models, tools, data, GIS, and supporting documentation. We are focusing on developing a common-look-and-feel user interface across these tools. As the first test case, we will integrate the MANPADS case study into RAW infrastructure. We will then conduct demonstrations of the tool’s operation to collect user feedback, and expand to other case studies.

**Outcomes:** The primary outcome is a software tool that provides modeling and analysis capabilities for the risk and decision analysis. It will also develop specifications for model and tool developers to follow when developing software to be integrated into the RAW infrastructure.

**Project lead:** Robert Neches, (310) 448-8481, rneches@isi.edu

**Deliverable:** First RAW prototype in early 2006.
17. Storage, Distribution and Dispensing of Medical Supplies

**Background:** The distribution and delivery of pharmaceuticals is an important element in emergency response. The US has a well-developed supply chain for normal demand. This project will describe the resources that are now available and that are relevant for use in response to acts of terrorism. Involved are drug manufacturers, distributors, hospitals, doctors and pharmacists. HMO’s, clinics and existing emergency services are also concerned. Issues include storage and distribution to doctor-patient locations and dispensing of medications and information. Coordination is also important and hospitals plan how they deal with emergencies on a regional basis.

**Goal:** Minimize Damage  
(1) To provide an understanding of the supply chain related to medical supplies and related issues concerning physical logistics, coordination and information sharing.  
(2) Overall coordination of hospitals regarding external emergency events will also be included.

**Approach:** A report was prepared based on interviews with personnel at hospitals, clinics, manufacturers, medical suppliers, retailers, pharmacists, emergency planners and others working on pharmaceutical matters. A detailed picture was developed regarding hospital planning for emergency events. A standard set of questions were followed to assure comprehensive and consistent results. Narrative and quantitative descriptions as well as flowcharts were developed.

**Outcome:** This effort documented the several steps involved in the storage, distribution and dispensing of medical supplies under non-emergency conditions as well as special arrangements that have been made for emergency conditions such as in the case of bioterrorism. The report is based on interviews with personnel at hospitals, clinics, manufacturers, medical suppliers, retailers, pharmacists, emergency planners and others working on pharmaceutical matters. Problems related to the emergency supply chain as well as suggestions are noted. There are two sections to the report; the normal supply chain and the emergency supply chain. Several solutions were suggested to various problems along the chain. These address the pharmaceutical information system, distribution management, RFID tags, vehicle routing, surge capacity, etc. Simply addressing them directly with consistent practices solves many of them. Also, sharing of solutions among jurisdictions seems particularly important since many of the supply chain problems apply to most geographic areas.

**Deliverable:** "Storage, Distribution, and Dispensing of Medical Supplies", CREATE Report.

**Project Lead:** David Belson, University of Southern California, (310) 839-2568, belson@usc.edu
18. Global Terrorism: Deterrence Versus Preemption

**Background:** This paper analyzes two anti-terrorism policies when a nation’s people and property are in jeopardy at home and abroad, as is true of the United States. A country’s deterrence decision at home involves both benefits and costs for other nations, not party to its policy choices. Benefits arise as foreign residents and assets are protected by the host nation’s actions to deter an attack, while costs stem from the potential terrorist attack being deflected abroad by such actions. In contrast, preemptive or offensive measures to attack a common threat (e.g., al-Qaida) yield primarily benefits to all at-risk nations. This theoretical paper contrasts deterrent and preemptive responses. With terrorist damages primarily limited to interests at home, a country will overdeter, while, for globalized terrorism, a country will underdeter. Preemptive measures are generally undersupplied as the providing country fails to account for benefits conferred on other would-be target nations. Leadership by a prime-target nation (e.g., the United States after 9/11 or the United Kingdom after July 7, 2005) lessens the inefficiency for deterrence but worsens the inefficiency for preemption. Given these different prognoses, targeted nations can never achieve the proper counterterrorism policy through leadership and independent action.

**Goal:** Prevent Terrorist Attacks. Using a theoretical framework, we show that nations will choose the wrong mix of deterrent and preemptive responses against a common transnational terrorist threat. The paper also demonstrates that actions by a nation to assume a leadership role may ameliorate some inefficiency while augmenting other inefficiencies.

**Approach:** We build a three-player game-theoretic model that involves two targeted governments and a terrorist group. The latter seeks to attack the softest target – i.e., the nation taking the least defensive measures. The paper identifies a host of externalities (i.e., uncompensated interdependencies among nations) that makes targeted nations work at cross-purposes with one another. The analysis also allows for one targeted country to act first (i.e., lead) with respect to the choice of deterrence or preemption and the other country to follow. The sequence of moves by the government is shown to influence the effectiveness of defensive and offensive policies. For example, leadership is more desirable for deterrence than for preemptive responses since it limits over-deterrence, but exacerbates undersupply of preemption. By treating nations as independent agents, the analysis identifies losses that arise when nations do not coordinate their antiterrorist policies. The analysis can provide an understanding of a host of countermeasures, including freezing terrorist assets and retaliatory raids.

**Outcome:** Todd Sandler and Kevin Siqueira, “Global Terrorism: Deterrence versus Preemption,” paper submitted to refereed journal. The paper analyzes two antiterrorism policies (deterrence and preemption) when a targeted nation’s people and property are in jeopardy at home and abroad. The study shows that countries undersupply preemption (i.e., actions to reduce a common terrorism threat) and oversupply deterrence (i.e., actions to defend against attacks at home). Leadership by a prime-target nation is shown to exacerbate the undersupply of preemption, while limiting the oversupply of deterrence. It is difficult for leadership to achieve the proper balance of counterterrorism measures. This study also shows that a lack of policy coordination by countries facing a common terrorist threat results in policy failures.

**Project Lead:** Todd Sandler, USC, 213-740-9695, tsandler@usc.edu
19. A Decision Analysis to Evaluate the Cost-Effectiveness of MANPADS Countermeasures

Background: This report describes a decision analysis to assess the cost-effectiveness of MANPADS (Man-Portable Air Defense Systems) countermeasures. These countermeasures are electronic devices that can be installed on commercial airplanes to detect and deflect surface-to-air missiles (SAMS) fired by terrorists. The model considers a terrorist attempt to shoot down a commercial liner with a heat seeking surface-to-air missile (SAM).

Goal: Prevent Terrorist Attacks. This project seeks to analyze external weapons threats to civil aviation, and to develop modeling tools that might be used to establish or parameterize comparative risk and related terrorism countermeasures policy. It assessed and modeled the potential risks to civilian aviation from external weapons, especially (but not limited to) MANPADS, and assessed possible cost-benefits of countermeasures to prevent or mitigate attack.

Approach: Comparative quantitative methods developed to establish or parameterize probabilities of threat, vulnerability and consequences. Decision tree parameterization tools for countermeasures analysis were developed and used. The analysis occurred in two stages: First, a decision tree model was built using the Treeplan software and all inputs were parameterized to cover a wide range of reasonable possibilities. A Visual Basic interface was established to create a user friendly and interactive tool to explore alternative sets of parameters. Use of this tool suggested that the probability of an attack, the total economic costs due to the attack, and the cost of the countermeasures were the key drivers of the decision of whether or not to equip commercial planes with MANPADS countermeasures. Subsequently another model was built in Treeage Pro, a tool that is especially valuable that for sensitivity analysis. The Treeage Pro model is also completely parameterized to account for the type of weapon, the type of aircraft, the location of delivery of the weapon, distance from the airplane, and possible countermeasures. While the model focuses on one attack, it can easily be adopted to multiple and possibly sequential attacks.

Outcome: Paper by Detlof von Winterfeldt and Terrence O'Sullivan, "A Decision Analysis Tool to Evaluate the Cost Effectiveness of MANPADS Countermeasures" to be published, Journal of Risk Analysis. The analysis suggests that countermeasures installed on planes to deflect heat seeking SAMs can be cost-effective, if the probability of such an attack is large (>0.5 in ten years), the losses are large (> $100 billion), and the countermeasures are relatively inexpensive (< $15 billion).

Lead: Detlof von Winterfeldt and Terrence M. O’Sullivan
20. Strategic Decision Making in Presence of Adversaries

**Goal:** Prevent Terrorist Attacks 1) Formulation of robust stochastic games 2) Existence of equilibrium points 3) Calculation of an equilibrium point 4) Application to MANPADS

**Approach:** A novel approach, robust stochastic games, is introduced. This work focuses on incomplete information stochastic games and adopts a robust approach to account for uncertainty present in the problem in two dimensions. First, it takes into account the uncertain adaptive nature of the adversary. A new approach is presented that accounts for the uncertainty in the conversion from one threat category to the other that is based on the alternatives of the adversaries. Second, it is considered that payoffs to the opponents are uncertain. A new result, existence of equilibrium points in robust stochastic games is proved. A new formulation that uses robust optimization techniques is presented to solve robust stochastic games. Preliminary results are presented on a simple example with partial unknown data. First, uncertain transition probabilities that belong to convex hull uncertainty sets are considered in this example with exact immediate costs. Next, uncertainty is considered in both transition probabilities and immediate costs. Comparison of robust and nominal solutions is presented subsequently.

**Outcome:** Formulation of robust stochastic game for the MANPADS model, data collection, and solution methodology for the model, leading to a journal publication of the methods and results.

**Lead:** Randolph Hall
Appendix C

Synopses of Year 2 Projects

Project 1: Terrorism and US Foreign Direct Investment, and Counterterrorism Policy Evaluation (Sandler)

This project investigates the impact of transnational terrorism on US foreign direct investment. The project also analyzes the practice of defensive and proactive counterterrorism measures in the face of a transnational terrorism threat.

Modeling Area: Risk Analysis
Case Studies Supported: Risk-Based Resource Allocation
Principal Investigator: Todd Sandler, USC
Other Investigators: Walter Enders, University of Alabama

Brief Description:
The project consists of two studies. The first is an empirical study that gauges the impact of transnational terrorism on US foreign direct investment (FDI) flows. This study employs both time-series and panel estimation techniques for a sample of countries during a given time frame. In the second study, game theory is applied to display the consequences of independent action by nations that face a common transnational terrorist threat. The analysis considers both deterrence and preemption policies. In a wide range of scenarios, independent actions will lead to suboptimal policy choices that can be improved through international cooperation.

Objectives and Technical Approach:
The project uses time-series and panel estimations to investigate to what extent terrorism alters US foreign direct investment (FDI) through the creation of a general climate of intimidation and fear. The study consists of two parts. The first part investigates the flow of US FDI immediately before and immediately after September 11, 2001 for select countries that experienced terrorist attacks. In the second part, the effects of terrorism on US FDI are investigated for a panel of countries for 1989-1999. We anticipate that US firms will shift their investments out of high-terrorism countries into low-terrorism countries to limit risk, business disruptions, and operating costs. The study measures one potential economic cost of terrorism in terms of reduced US FDI.

The second study uses game theory (non-cooperative) to analyze two antiterrorism policies (deterrence and preemption) when a targeted nation’s people and property are in jeopardy at home and abroad. The study shows that countries undersupply preemption (i.e., actions to reduce a common terrorism threat) and oversupply deterrence (i.e., actions to defend against attacks at home). Leadership by a prime-target nation is shown to exacerbate the undersupply of preemption, while limiting the oversupply of deterrence. Unfortunately, leadership can never achieve the proper balance of counterterrorism measures. This second study shows that the lack of policy coordination by countries facing a common terrorist threat results in policy failures.

Major Products and Customers: Two articles submitted to refereed journals.
Project 2a: Innovations in Risk and Economic Modeling of Counter-Terrorism (Bier)

This work combines game theory and risk analysis to identify optimal strategies for defensive investment in counter-terrorism, taking potential adversary responses into account.

**Modeling Area:** Risk Analysis

**Case Studies Supported:** Risk-based Resource Allocation

**Principal Investigator:** Vicki Bier

**Institution:** University of Wisconsin-Madison

**Other Investigators:** Larry Samuelson

**Student Research Assistants:** Uche Okpara, Santiago Oliveros, Natawan Teerapirak, Jun Zhuang

**Brief Description:**
This work studies the optimal allocation of defensive resources in complex systems. The approach combines risk analysis and game theory to anticipate which components are likely to be targeted in a potential attack (based on assumed terrorist goals and constraints), and determine the optimum allocation of defensive resources.

**Objectives:**
The goal of this research is to expand the existing tools and techniques of risk analysis to more effectively address security considerations, taking into account the fact that terrorists can observe our defenses and adapt their strategies accordingly.

**Major Products and Customers:**
- Techniques for vulnerability assessment and portfolio allocation that could be used by facility owners or managers in the public and private sectors
- Models and guidelines for the optimum (most cost-effective) allocation of defensive resources, as a function of system structure and attacker goals and motivations
- Guidelines on the circumstances under which secrecy and/or deception are appropriate in defending against terrorism, and when publicly known defenses provide better deterrence

**Interfaces to other CREATE Projects:**
This project will contribute to the case study on resource allocation. It also relates to the work being done on critical infrastructure protection, and to basic methodological work being undertaken in other projects (e.g., development of software for portfolio allocation, modeling of terrorist decision processes).

**Interfaces to non-CREATE Projects:**
Project personnel are working closely with the National Center for Foreign Animal and Zoonotic Disease Defense at Texas A&M University, to apply risk analysis, uncertainty analysis, and decision analysis to the threat of foot-and-mouth disease in the livestock industry. We are also exploring collaboration with the National Center for Food Protection and Defense at the University of Minnesota, looking at interdependent security risks in the supply chains for grain,
dairy, and other types of food products. Finally, work is ongoing on a grant funded by the Army Research Office in the area of critical infrastructure protection for computer and telecommunications security.

**Technical Approach:**
Traditional economic game-theoretic models of defense fail to give adequate consideration to the complex networked structures of the systems that we are interested in defending. By contrast, risk analysis generally neglects the fact that terrorists are intelligent and adaptive, and can observe our defenses and adapt their strategies accordingly. By combining both approaches, we can adequately reflect both the adaptive nature of terrorist threats and the structures of the systems to be defended.

Key theoretical and modeling issues to be addressed include:

1) Extending existing models to explore the different implications for policy making and investment strategy of intentional threats (such as terrorism) and non-intentional threats (such as natural disasters)—see milestone 1 below.
2) Extending existing models to explore the circumstances under which it is better to disclose defensive investments (in order to deter potential terrorists), versus those circumstances under which secrecy or even deception may be better strategies for the defender—see milestone 4 below.

It is also of course important to apply existing models to realistic case studies, as a way to gauge the realism of the results. At present, we plan to apply existing results from year 1 to case studies on:

1) Transportation and network security—see milestone 3 below.
2) Optimal allocation of defensive resources among cities—see milestone 5 below.

Finally, the scarcity of data on many important inputs to risk and economic models of terrorism suggests that expert judgment will frequently be needed. This can raise questions about the objectivity and calibration of expert opinion. To address this question, we are performing a statistical analysis of expert judgments from past risk studies, to help identify some of the factors affecting expert calibration, and ways to achieve improved calibration. The results should provide guidance on the use of empirical methods for improving calibration. Note that the empirical basis of the approach being adopted here may be especially helpful in achieving consensus in politically heated and controversial areas, such as terrorism. See milestone 2.

**Major Milestones and Dates:**
2. Submit manuscript on the use of expert judgment to *Decision Analysis* -- January 2006.
3. Write up results of a model on transportation and network security for submission to the *Journal of Infrastructure Systems* -- March 2006.
5. Apply existing methods to the problem of resource allocation among cities -- May 2006.
Project 2b: Resource Allocation in the Context of Bioterrorism (Bier)

This work will explore the use of performance-based design for allocating security resources among different types of buildings in the context of bioterrorism.

Modeling Area: Risk Analysis
Case Studies Supported: Risk-based Resource Allocation, Bioterrorism
Principal Investigator: Vicki Bier
Institution: University of Wisconsin-Madison
Other Investigators: Larry Bank
Student Research Assistants: Ben Thompson

Brief Description:
We will explore the use of performance-based design for allocating security resources among different types of buildings (e.g., to ensure that greater resources are allocated to higher-risk and/or more critical buildings). This idea could be applied both to retrofitting of existing buildings, and to design of new construction. The method will be illustrated with a case study involving release of a biological agent into the ventilation system of a building.

Objectives:
The goal of this research is to expand the existing tools and techniques for building design to more effectively address security considerations.

Major Products and Customers:
Techniques for performance-based design and resource allocation that could be used by facility owners or managers in the public and private sectors.

Interfaces to other CREATE Projects:
This project is closely related to the case study on resource allocation, and is supporting the case study on bioterrorism. It also relates to the work being done on critical infrastructure protection.

Technical Approach:
The basic approach involves the use of performance-based design methods. In particular, work will be undertaken on how to incorporate both risk analysis and risk perception in performance-based design, in the context of terrorism-resistant design. The work will proceed using a case-study approach, involving a case study on bioterrorism.

Major Milestones and Dates:
2. Work on familiarization with design of non-structural building systems -- January 2006.
3. Determine appropriate methodology for characterizing terrorist threats to buildings in terms of severity and likelihood -- January 2006.
5. Support bioterrorism case study at USC (as required).
Project 2c: Risk Assessment and Analysis for Improved Planning for Foreign Animal & Zoonotic Disease Defense (Bier)

This work applies risk analysis, uncertainty analysis, and decision analysis to the intentional introduction of foot-and-mouth disease, as a basis for identifying the most desirable risk-management options, and key research and data needs.

**Modeling Area:** Risk Analysis  
**Case Studies Supported:** Bioterrorism  
**Principal Investigator:** Vicki Bier  
**Institution:** University of Wisconsin-Madison  
**Other Investigators:** Zach, Najm Meshkati, Michael Orosz, Terry Benzel

**Brief Description:**
This work uses risk analysis and uncertainty analysis to study intentional introduction of foot-and-mouth disease, in a case study involving feedlots in the Texas panhandle. In particular, we will apply two-dimensional Monte Carlo to epidemiologic, economic, and other models being developed at Texas A&M University, to quantify uncertainty (as well as the variability already addressed by the current models). We will also use decision analysis and decision support to present the results of this complicated analysis to decision makers.

**Objectives:**
The goal of this research is to develop a risk-based understanding of alternative risk-management options for controlling animal diseases that would lower the total long-run expected cost, as well as event-to-event costs.

**Major Products and Customers:**
- A user interface allowing decision makers to explore mitigation options for animal diseases, to be used by federal, state, and local agencies, as well as private firms
- A protocol and analytical tools to facilitate risk and uncertainty assessments based on linked systems of models for animal diseases

**Interfaces to other CREATE Projects:**
This project is closely related to the development of the Risk-Analysts’ Workbench (RAW), and is also related to the case study on bioterrorism.

**Interfaces to non-CREATE Projects:**
Project personnel are working closely with the National Center for Foreign Animal and Zoonotic Disease Defense at Texas A&M University.
Technical Approach:
Traditional epidemiologic models typically consider only variability (the fact that a given outbreak of disease can either explode or die out, depending on what happens following the start of the outbreak). However, they often fail to give adequate consideration to the fact that there is substantial scientific uncertainty about many of the parameters of the models (e.g., measures of disease infectivity). By combining uncertainty analysis with more traditional simulation approaches using two-dimensional Monte Carlo, we hope to more accurately reflect the true extent of the uncertainty about disease risks.

Major Milestones and Dates:

1. Develop decision framework, software specification, and data needs -- March, 2006
2. Conduct in-house expert elicitation and uncertainty analysis -- March, 2006
3. Quantify impact of human actions and interventions -- April, 2007
4. Results and publications -- Mid 2007
Project 3: Decision Analysis to Counter Terrorism (von Winterfeldt)

This project provides decision analysis support for the case studies and will develop and test advanced decision analysis tools for evaluating policy alternatives.

Modeling Area: Risk Analysis
Case Studies Supported: Dirty Bomb, MANPADS, Bioterrorism, Risk-based Resource Allocation
Principal Investigator: Detlof von Winterfeldt
Institution: University of Southern California
Other Investigators: Richard S. John., Don Kleinmuntz
Student Investigators: Heather Rosoff, Sonia Solin, Carl Southwell

Brief Description:
Decision analysis consists of a set of models and tools to improve decisions with multiple objectives and risks. Together with risk analysis, decision analysis is one of the main approaches that the CREATE team uses to evaluate alternative policies to reduce the risks and consequences of terrorism. In the first year, decision analysis models and computer tools were developed to evaluate MANPADS countermeasures and to assess the risks of a dirty bomb attack on LA harbor. In the first case, a relatively traditional cost-effectiveness version of a decision tree analysis was developed. In the second case, a novel approach was developed that uses project risk analysis to reverse engineer a terrorist attack. In the second year, decision analysis will be applied to the bioterrorism case by developing models of terrorists’ decisions to select a preferred biological agent. It will also be used to improve risk-based resource allocation models.

Objectives and Technical Approach:
This research will develop advanced methods of decision analysis for the evaluation of alternative policies to counter terrorism. This project will apply and test the tools in selected case studies. Decision analysis is a mature methodology that is useful for improving decisions with multiple objectives and risks. Together with risk analysis, decision analysis is one of the analytical backbones of CREATE’s applied research. While risk and decision analysis are fairly mature methodologies, advances are needed to use them effectively to make better decisions to counter terrorism.

Interfaces to other CREATE Projects:
This work will maintain a close connection with the economics impact analysis tasks, and collaborate with several case study projects to provide decision analysis support.

Interfaces to non-CREATE Projects:
This work will be conducted in collaboration with the National Atmospheric Release Advisory Center (NARAC) at the Lawrence Livermore Laboratory on dirty bomb plumes; collaboration with Battelle PNNL on the economic costs of decontamination of radioactive materials; collaboration with the MANPADS Countermeasure Office at the DHS; collaboration with the National Biodefense Analysis and Countermeasures Center (NBACC) to review risk assessment methods for biological agents; collaboration with the California Department of Health Services.
to assess the costs and benefits of the indoor Biowatch program; collaboration with the California Governor’s Office of Homeland Security to prioritize infrastructure sites in California.

**Major Products and Customers:**

- **MANPADS:** Two decision analysis models and user-friendly computer tools to evaluate countermeasures to heat seeking surface-to-air missiles for the MANPADS Countermeasures office at the DHS; one journal article submitted in November, 2005
- **Dirty bomb/LA and Long Beach Harbor:** Project risk analysis model and associated computer tools of a dirty bomb attack on LA and Long Beach Harbors for use by the IP directorate and harbor security officials; one journal article submitted in November, 2005

**Major Milestones and Dates:**

- **MANPADS case study, models, and computer tools completed and delivered to DHS’ MANPADS Countermeasures Office; updates delivered in December 2005.**
- **Dirty bomb case study, models, and computer tools completed and presented to the DHS.**
- **First draft of a new edited book “Advances in Decision Analysis” completed and posted on the CREATE web site; the publisher is Cambridge University Press and we expect delivery of all edited chapters to CUP by the end of February, 2006 with a publication date in 2006.**
- **Draft paper on resource allocation (Kleinmuntz) and conceptual model for using risk reduction as a major objective in resource allocation completed -- December 2005.**
- **Model for terrorists’ choices of a biological agent completed -- January 2006.**
- **Project risk analysis for an anthrax attack completed -- March 2006.**
Project 4: Risk-Based Allocation of Resources to Counterterrorism (Kleinmuntz)

This project is developing methods for using the output of sophisticated threat assessment models to optimally allocate resources to counter bioterrorism.

**Modeling Area:** Risk Analysis  
**Case Studies Supported:** Risk-Based Resource Allocation  
**Principal Investigator:** Don Kleinmuntz  
**Institution:** University of Illinois, Urbana-Champaign  
**Other Investigators:** Detlof von Winterfeldt, USC, Vicki M. Bier, University of Wisconsin, Madison

**Brief Description:**  
The purpose of this research is to improve methods for risk-based allocation of resources to counterterrorism measures. This work builds on CREATE efforts to develop threat assessments for such areas as biological weapons attacks by using those threat assessments as inputs to models designed to help DHS optimally allocate investments intended to counter bioterrorism. In addition, we will address the problem of allocating state grants for emergency responders. The purpose of this work is to provide sound analytical guidance to decision makers regarding the most effective way to obtain maximum impact from a given funding level.

**Objectives:**  
This research will (a) develop one or more comprehensive methodologies for risk-based resource allocation among discrete counterterrorism measures; (b) perform feasibility testing of these methods through application to actual data on bioterrorism threat reduction measures; (c) develop one or more comprehensive methodologies for allocation funding where the decisions are selection of continuous funding levels rather than discrete counter measures; (d) perform feasibility testing of these methods through application to the problem of allocating state grants for emergency responders; (e) summarize and evaluate the conceptual and practical soundness of alternative risk-based resource allocation strategies, including comparing the methods developed to allocations developed by other methods and approaches.

**Interfaces to other CREATE Projects:**  
This work will maintain a close interface with the risk analysis and economics projects.

**Interfaces to non-CREATE Projects:**  
We are working with the Infrastructure Protection division of the DHS to use their RAMCAP methodology for prioritizing risks, and with the California Office of Homeland Security to implement a pilot study to prioritize California sites in terms of risks and risk reductions. We also plan to collaborate with Lawrence Livermore National Laboratories’ HOPS program to provide risk assessments.
**Major Products and Customers:**
Project deliverables will consist of a report that will: (a) develop one or more comprehensive methodologies for risk-based resource allocation among discrete counterterrorism measures; (b) perform feasibility testing of these methods through application to actual data on bioterrorism threat reduction measures; (c) develop one or more comprehensive methodologies for allocation funding where the decisions are selection of continuous funding levels rather than discrete counter measures; and (d) perform feasibility testing of these methods through application to the problem of allocating state grants for emergency responders; (e) summarize and evaluate the conceptual and practical soundness of alternative risk-based resource allocation strategies, including comparing the methods developed to allocations developed by other methods and approaches. Customers: DHS – IP; DHS – ORD; California OHS

**Products:** Risk assessment methodology for prioritizing projects and programs and to gauge the cost/effectiveness of investments in risk reductions; research publications and reports.

**Technical Approach:**
The methods developed will build on previous research on decision analysis methods for resource allocation and the use of mathematical programming for optimal resource allocation. Consequence assessment models and risk reduction assessments will be based on a mix of methodologies including probabilistic risk analysis, economic analysis, and qualitative assessments by experts, as appropriate. Methods for combining these assessments will be grounded in the theory and methods of multiattribute utility and value models. The overall resource allocation framework uses mathematical programming including linear, nonlinear, and integer programming.

**Major Milestones and Dates:**
1. Develop risk and consequence measures to reflect the impact of terrorism events and a multidimensional risk index that combines these diverse risk and consequence measures based on policy makers’ judgments about the relative severity of consequences -- March 2006.
2. Incorporate the risk reduction measures into a risk allocation model that takes into account both the effectiveness of various alternatives and their cost -- June 2006.
4. Explore extensions of model to account for continuous expenditure levels -- October 2006.
Project 5: Risk Analysts’ Workbench (Neches, Orosz)

RAW is a software platform that enables policy/decision-makers and risk analysts to share computing tools, models, data, analysis and results, and supports each in their unique roles and needs in risk-sensitive planning.

Modeling Area: Risk Analysis, Decision Support
Case Studies Supported: Bioterrorism, Border-Security, Risk-based Resource Allocation
Principal Investigator: Robert Neches
Institution: USC Information Sciences Institute
Other Investigators: Mike Orosz, Terry Benzel
Student Research Assistants: Jennifer Chen

Brief Description:
The Risk Analysts’ Workbench (RAW) is an approach to serving both policy/decision-makers and risk analysts in a common framework, enabling synergies which help both more effectively perform their individual roles in assessing terrorism threats and evaluating strategies for countering those terrorist threats. Its coverage spans risk assessments and models, decision support tools, scenario and threat definitions, supporting data, and presentation and review tools. The workbench will be capable of integrating different risk and consequence models in a common user and data set management interface. The user interface will allow for the creation and specification of new scenarios and models for analysis, management of existing scenarios, sharing of scenarios among multiple analysts, roll-up into composite analyses, and review of combined scenarios by policy developers and decision makers.

Objectives:
- Establish RAW server containing CREATE risk models and decision-support tools, databases, scenario definitions, supporting documentation, and assessment results/reports
- Develop the initial RAW common-look-and-feel user interface (UI).
- Develop an initial RAW prototype that includes the models, tools, data, and current risk assessments of the initial CREATE MANPADS case study.
- Extend the prototype to include the tools, data, and information to support research and decision–support analysis for case studies in bioterrorism and/or border security threats

Major Products and Customers:
- Prototype software that support analysis into MANPADS threats, selected bioterrorism threats, and/or a selected border security threats
- Prototype software that includes a common-look-and-feel user interface that aids the risk analyst/researcher and policy/decision-makers
- RAW server containing CREATE models, software, data, and reports that support MANPADS, bioterrorism, and/or border security case studies
The intended customers include the following:

- Both CREATE and non-CREATE researchers in risk and decision analysis
- State and local government decision-makers
- DHS researchers and decision-makers

Interfaces to other CREATE Projects:
RAW will integrate tools, data, and assessments from the MANPADS case study and one or more case studies from the bioterrorism and border security projects

Interfaces to non-CREATE Projects:
RAW is being extended to include tools, data, and risk/threat assessments from several case studies from the DHS sponsored National Center of Foreign Animal and Zoonotic Diseases Defense (FAZD) center at Texas A&M.

Technical Approach:
1. Requirements and design specification refinement
   a. Interview subject matter experts (SMEs)
      i. Determine how SMEs do business
      ii. Compile list of tools, data, and supporting documentation used in risk assessments
      iii. Compile list of problems with current approaches
      iv. Compile list of desired features/functions SMEs would like to see if RAW
   b. Update existing requirements/design specification
2. Develop initial prototype
   a. Establish server at ISI
      i. Populate with CREATE models, tools, data, GIS, and supporting documentation
   b. Develop initial common-look-and-feel user interface (UI)
   c. Integrate MANPADS case study into RAW infrastructure
   d. Demonstration – collect user feedback
3. Develop second prototype
   a. Extend server capabilities at ISI to support additional case studies, models, tools, data, and supporting documentation
   b. Extend common-look-and-feel user interface based on user community feedback
   c. Integrate into RAW models, tools, data, and supporting documentation from bioterrorism and/or border security case studies
4. Initial development of RAW model/tool interface protocol. Specification for model and tool developers to follow when developing software to be integrated into the RAW infrastructure

Major Milestones and Dates:
1. User interface prototype – Completed, November 2005
2. Establish RAW server – December 2005
3. First RAW prototype (support MANPADS case study) – January/February 2006
4. Second RAW prototype – April/May 2006
5. Initial modeling/tool interface protocol – August 2006
Project 6: Network Reliability Models (Ross)

This research will develop and analyze new network reliability models that allow for component dependencies.

**Modeling Area:** Risk Analysis  
**Principal Investigator:** Sheldon Ross  
**Institution:** University of Southern California  
**Student Research Assistants:** Samim Ghamami

**Brief Description:**  
Very few network reliability models allow the component reliabilities to be dependent, greatly limiting their applications. One exception has been cascading failure models, in which the failure of a component adds additional loads to as-yet-unfailed components, possibly causing their failure. Recent work has derived the probability distribution of the number of failed components that result from such a model. However, such information does not enable one to computationally determine the probability that the resulting network system will remain operable. We propose to deal with this problem as well as more general dependent models.

**Objectives:**  
This research seeks to develop effective simulation procedures to efficiently determine the probability that a network system of possibly dependent components will function.

**Major Products and Customers:**  
The network reliability model can be used in all risk analysis projects involving networks, e.g., electrical and other infrastructure networks.

**Interfaces to other CREATE Projects:**  
Collaboration with risk analysis teams and projects.

**Interfaces to non-CREATE Projects:**  
No current direct collaborations with non-CREATE projects are expected.

**Technical Approach:**  
The technical approach consist primarily of basic research and mathematical modeling.

**Major Milestones and Dates:**  
Project 7: Geographic Information Systems (GIS) Support (Bowman)

This effort builds Geographic Information System (GIS) interfaces and applications and performs GIS analysis to support CREATE research projects.

**Modeling Area:** All  
**Case Studies Supported:** All  
**Principal Investigator:** Harry Bowman  
**Institution:** University of Southern California

**Brief Description:**  
CREATE research relies on spatial data, models of spatially distributed phenomena, or relies on maps to communicate results. GIS software manages spatial data, provides a framework for spatial modeling, and can be used to create maps. This effort provides support to other CREATE research projects for GIS analysis (data and maps) and building applications to integrate with other CREATE research software.

**Objectives:**  
- Provide useful spatial data management, analysis, and mapping to other research teams.  
- Develop GIS applications to enhance and integrate other CREATE research software.

**Major Products and Customers:**  
The primary products of this effort are spatial datasets, maps, components and applications. Its primary customers are other CREATE researchers. Other customers include DHS operational offices, DHS Science and technology clients, and California’s Office of Homeland Security.

**Interfaces to other CREATE Projects:**  
The current major interfaces are with the Dessouky/Ordonez emergency supply distribution project, and with the Risk Analysts’ Workbench (RAW). There are other interfaces on ad hoc basis, including to Tambe’s responder training project and to the Richardson/ Gordon/Moore economics project.

**Interfaces to non-CREATE Projects:**  
This effort provides data, maps, and software to the LA County Strategic National Stockpile (SNS) project.

**Technical Approach:**  
The approach is to primarily use the ESRI ArcGIS platform, both as an application for managing data and maps and also as an API for application development. Other platforms can be used for application development as the need arises. The products developed for each supported project vary and can include custom report generators, maps and data sets on servers or locally distributed, custom user interfaces integrated into the GIS environment, and software components for spatial analysis to be deployed within the supported project’s software.

**Major Milestones and Dates:**  
1. Complete initial phase of SNS project requirements -- December 2005.  
2. Complete Dessouky/Ordonez interface -- January 2006  
Project 8: Economic Impact Modeling and Analysis (Gordon et al.)

This research is developing models and data for performing economic analysis in spatial detail with the objective of analyzing the economic impact of terrorism events and natural disasters.

Modeling Area: Economic Analysis
Principal Investigators: Peter Gordon, Harry Richardson, and James Moore
Institution: University of Southern California
Student Research Assistants: Jiyoung Park, Bumsoo Lee, Soojung Kim, and Mayank Mohan

Brief Description:
This research consists of a series of studies on the economic impact of a variety of terrorist attacks and natural disasters in the United States. These studies use either or both of two economic impact models, the SCPM (the Southern California Planning Model) and NIEMO (the National Interstate Economic Model) to analyze the economic effect of major disasters on various key infrastructure installations and other important sites. SCPM is an interindustry input-output model, based on transaction flows between intermediate suppliers and end producers, spatially specific to Southern California. The NIEMO model traces interregional economic effects of events across the US.

Objectives:
This research seeks to develop and apply methodologies and models that assess the economic impacts of various terrorist attacks and natural disasters. SCPM will be used to estimate dollar losses from selected events, and how these losses are geographically distributed throughout Southern California. We will also extend NIEMO so that it has additional supply-side economic impact estimation capabilities, and estimate the state-by-state and sectoral impacts of Hurricane Katrina, highlighting separate demand-side and supply-side effects.

This effort will also assemble leaders in the economics and risk analysis of terrorism and natural disasters to present papers and exchange ideas; publish and disseminate the findings in the Third CREATE Economics Symposium.

Major Products and Customers:
• The results of the economic analyses will be used by local planners and security officials.
• The economic analyses models will be used by researchers worldwide.
• The Third CREATE Economic Symposium will be published and widely disseminated.

Interfaces to other CREATE Projects:
This work interfaces intensively with the Economics Analysis work of Adam Rose and Lester Lave, and all the CREATE case studies.
Interfaces to non-CREATE Projects:
This effort will interface directly with the FAZD DHS center on the overall evaluation of mad cow and foot-and-mouth disease and its economic impact assessments. The Third Economics Symposium will assemble leading economists and risk analysts who have studied major events, focusing on Hurricane Katrina and its after-effects.

Technical Approach:
2. Compare sectoral aggregation errors and compare to spatial disaggregation benefits of NIEMO.
3. Apply NIEMO to study of the state-by-state effects of Hurricane Katrina.
4. Apply NIEMO to study of mad cow and foot-and-mouth disease scenarios.
5. Prepare for Third CREATE Economics Symposium, to be held at USC in August of 2006. This one will include economic impacts and risk analysis papers that focus on recent hurricanes that hit the U.S. Gulf Coast.
6. Prepare reports for journal submission.

Major Milestones and Dates:
1. Analysis of ports closure and radiological plume impacts – January 2006
2. Comparisons of sectoral aggregation errors and spatial disaggregation benefits of NIEMO – March 2006
3. Assessment of state-by-state effects of Hurricane Katrina – April 2006
Project 9: The Role of Public and Private Mitigation for Homeland Security Policy (Smith)

This research examines how private risk perceptions and mitigation plans are affected by private individuals’ knowledge and evaluation of public activities to reduce threat and consequence. Particular attention is directed to the factors that create or enhance the perception on the part of private individuals that their actions enhance (or complement) public activities.

**Modeling Area:** Economic Analysis  
**Principal Investigators:** V. Kerry Smith  
**Institution:** RTI International  
**Other Investigators:** Carol Mansfield, Brian Murray

**Brief Description:**  
DHS efforts to reduce risk must necessarily be undertaken *ex ante*. Efforts associated with reducing consequences can involve *ex ante* preparation as well as *ex post* action. In principle both the public sector and private agents can be involved in both sets of activities. This research focuses on the design of public activities in ways that create incentives for supporting private responses. In economic terms these incentives arise when the activities from public and private sectors are complementary. There is a large literature on the nature of the incentives for private provision of public goods, but most of this research considers situations where private and public actions are substitutes. In this case, increases in public intervention and action can cause private activities to decline because the two are substitutes. During the past year the research associated with the project focused largely on what could be learned from natural experiments involving hurricanes and flooding.

**Objectives:**  
This research seeks to meet three objectives:  
1. Explore the factors that create private/public complementarities in activities that reduce the risk and/or consequences of actions associated with homeland security;  
2. Develop lessons about risk perception, adjustment and mitigation from past natural hazards that is transferable to situations involving homeland security;  
3. Develop a survey tool for obtaining representative questions, and deploy to obtain insight.

**Major Products and Customers:**  
The major product of this effort will be a survey of U.S. households’ willingness to undertake private mitigation activities that would reduce the vulnerability of regional as well as the national economy and health delivery system to terrorist activities. This would be used by public policy decision makers and DHS officials in formulating policies on security measures. Also, three journal articles are projected from this research.
Technical Approach:
1. Background Research for Scenario Design -- Obtain specific, credible descriptions of threats and *ex ante* behaviors, determine sensitive dimensions of the economic and health delivery systems to characterize 8 to 10 alternatives.
2. Conduct Focus Groups -- Collect contextual information, evaluate questions framing and collect “data” from a highly selected sample.
3. Design and Implement Internet Questionnaires -- Conduct survey of private households’ willingness to undertake mitigation, risk perceptions and responses to information.
4. Evaluate Survey Responses -- Summarize and extract lessons from the background research and focus groups, evaluate the stated choice responses estimating households’ willingness to pay to avoid disruptions in infrastructure and health related services relates to private and public mitigation activities, summarize risk perceptions and attitudes toward public policies and information programs associated with homeland security.

Major Milestones and Dates:
1. Background Research for Scenario Design -- November 2005
2. Conduct Focus Groups – December -- January 2005
3. Design and Implement Internet Questionnaires -- January-February 2006
4. Evaluate Survey Responses -- March 2006
Project 10: Economic Impact Modeling and Analysis with Computable General Equilibrium Models (Rose)

This project involves the extension and application of a state of the art model to analyze the economic impacts of terrorist attack at the individual business, market, and regional economy levels.

**Modeling Area:** Economic Analysis  
**Case Studies Supported:** Bioterrorism  
**Principal Investigator:** Adam Rose  
**Institution:** Penn State University  
**Other Investigators:** Gbadebo Oladosu (Oak Ridge National Laboratory), Shu-Yi Liao (National Chung Hsing University)  
**Student Research Assistants:** Dan Wei, Hubert Huang

**Brief Description:**  
Computable general equilibrium (CGE) analysis is the state of the art tool for analyzing the economic impacts of terrorist attacks on individual businesses, markets, and the regional economy. This project will extend CGE modeling conceptually through the incorporation of household production functions that will make it possible to evaluate the impact of terrorist attacks on residences, which consume about 30% of the electricity and 40% of the water services in the economy. The project will extend CGE modeling empirically by sharpening the accuracy of the measurement of resilience to attacks. Simulations will be performed with the enhanced model to examine the impacts of major water contamination and of an anthrax attack in Los Angeles.

**Objectives:**  
The goals of this project are to: 1) further refine a computable general equilibrium (CGE) model developed to analyze the regional economic impacts of terrorist attacks, and 2) to apply the model to bioterrorism case studies.

**Major Products and Customers:**  
The Los Angeles CGE Model tool will be useful to the Business Community and City County Officials. The Case Study Analyses will be useful to Utility Managers, the Business Community, and Emergency Management Officials.

**Interfaces to other CREATE Projects:**  
This project will enable comparison to studies by Zimmerman & by Lave on economic impacts of utility outages, provide economic advice and modeling to the Bioterrorism Case Study researchers, and provide economic advice to USC economics team on enhancing their models.

**Interfaces to non-CREATE Projects:**
This work complements research funded by the Multidisciplinary Center for Earthquake Engineering Research on economic impacts of utility disruptions caused by natural hazards, and other effort for DHS on indirect impacts of terrorist attacks.

Technical Approach:
This project will capitalize on the principal investigator’s recent refinements of CGE analysis, such as the collection of new empirical data, development of algorithms for their use in recalibrating key model parameters, modeling of disequilibria, decomposition of direct and indirect impacts, and its application to measuring economic resilience to disasters. Key steps for the coming year include updating and extending the CGE model, applying it to the Bioterrorism Case Study, applying it to utility outages, and developing lessons learned that can be shared with the USC economic analysis team.

Major Milestones and Dates:
1. Work with USC Economists to incorporate prices into USC model – April, 2006
2. Update and extend existing LA CGE Model – May 2006
3. Work with the Bioterrorism Group – May 2006
4. Application to utility outages – August 2006
Project 11: Assuring Essential Services during a Bioterrorism Attack (Lave)

This project will conduct an cost-effectiveness analysis of alternative means to provide essential services to the US population after a major bioterrorism attack.

**Modeling Area:** Economic Analysis  
**Case Studies Supported:** Bioterrorism  
**Principal Investigator:** Lester Lave  
**Institution:** Carnegie Mellon University  
**Other Investigators:** TBD  
**Student Investigators:** TBD

**Brief Description:**
This project consists of an investigation of how to assure the continuation of essential social services in the event of a bioterrorism or other attack or natural disaster. We differentiate an attack using a communicable infectious disease, such as small pox, from a bioterrorism attack that uses a non-communicable infectious disease, such as anthrax, or a toxic substance, such as Ricin. The former case is more difficult since all those potentially exposed, including health care professionals, would be at risk from the infection and could infect others. Once the risk of infecting others is controlled, the two cases would be similar: Victims would need to be identified and treated, while their crucial roles were filled by others, e.g., police, firemen, EMTs.

Each type of attack, natural disaster, or mishap would have its own precipitating events and immediate interventions. However, after the first few intervention steps, all or almost all of the precipitating events would lead to the same set of interventions needed to continue vital social services. The basic services needed for public health and safety are the same: The population needs to have water, food, shelter, and protection from criminals during a period when normal operations have been disrupted or even destroyed. The basic issues investigated for a bioterrorism attack will give solutions helpful to a wide range of disruptions.

**Objectives**
To assure that basic social services during a bioterrorism attack are delivered cost-effectively.

**Technical Approach:**
1. Characterize the range of services that a city of several hundred thousand needs to keep its residents healthy and safe, while preserving private and social assets, when normal operations are interrupted by illness or death of a proportion of the population, or the destruction or disruption one or more essential services, such as electricity.  
2. Examine the points of vulnerability of residents and assets these challenges.  
3. Characterize ways in which the essential services, public and private, could be continued in the face of such an attack or natural hazard.  
4. Evaluate these approaches for effectiveness and cost.  
5. Evaluate these approaches for their ability to continue services under a wide range of attacks and natural hazards.
6. Given the occurrence probabilities of the non-terror challenges, what would have to be the frequency and scale of terror attacks to create net benefits for each of the interventions found to be effective in step 4?
7. Present briefings at the midpoint and conclusion of the analysis.
8. Present progress reports at the midpoint of the project and a manuscript detailing the results of the analysis.

**Interfaces to other CREATE Projects:**
This project will collaborate closely with the risk analysis projects and with the bioterrorism case study.

**Interfaces to non-CREATE Projects:**
Collaboration with the National Biodefense Analysis and Countermeasure Center and the staff of the DHS Chem-Bio Portfolio.

**Major Products and Customers:**
DHS S&T, NBACC, local and regional health agencies.

**Major Milestones and Dates:**

TBD
Project 12: Risk Perception and Behavioral Economics (John, et al.)

This project reviews the relevance of risk perception and behavioral economics research for disasters involving terrorism and conducts pilot studies in risk perception and behavioral economics.

**Modeling Area:** Risk Analysis, Economic Analysis

**Case Studies Supported:** Bioterrorism, Risk-Based Allocation

**Principal Investigator:** Richard John  
**Institution:** University of Southern California  
**Other Investigators:** Raphael Bostic, Chris Redfearn  
**Student Investigators:** Heather Rosoff

**Brief Description:**
To assess the economic impacts of terrorism, it is important to understand, how the public perceives terrorism risks and reacts to terrorist attacks. While there has been much research of public perceptions of health and safety risks and behavioral responses to them, there has been very little research on perceptions and behavioral responses to terrorism risks. This project will fill this gap both by reviewing existing literature and conducting some pilot studies. Larger studies will be conducted in collaboration with the other University Centers of Excellence, especially with the START center.

**Objectives and Technical Approach:**
This research will first review existing research on terrorism risk perception and examine the relevance of this literature and of the behavioral economic literature for terrorism policy. It will also conduct pilot studies to assess terrorism risk perceptions and to gauge behavioral responses.

**Interfaces to other CREATE Projects:**
This work will maintain close interface with the risk analysis and economics projects.

**Interfaces to non-CREATE Projects:**
The main interface will be with a major planned study of risk perception, conducted with funding from the Integrated Network of Centers (INC). The START center will be a key collaborator.

**Major Products and Customers:**
This is a more fundamental research area with no direct linkage to DHS or other government customers. We expect that the main initial customers of this research will be the economic analysts at CREATE and within DHS who will assess the economic impacts of terrorism, based on assumptions and scenarios about behavioral responses of the public.

**Major Milestones and Dates:**
- Review of risk perception literature relevant to terrorism -- March 2006.
- Pilot study on terrorism risk perception -- March 2006.
- Risk perception workshop (INC funded) -- June 2006.
Project 13: Emergency Supply Planning (Dessouky and Ordonez)

This project is developing a decision tool to guide emergency response planners in determining where to locally store supplies and the best strategy to disburse the supplies.

**Modeling Area:** Risk Management  
**Case Studies Supported:** Bioterrorism  
**Principal Investigator:** Maged Dessouky  
**Institution:** University of Southern California  
**Other Investigators:** Fernando Ordóñez  
**Student Research Assistants:** Hongzhong Jia, Zhihong Shen

**Brief Description:**
A key ingredient in an effective response to an emergency is the prompt availability of the necessary supplies at the emergency sites. For example, to address out-breaks of infectious diseases, the Federal government's Strategic National Stockpile contains 300 million doses of small-pox vaccines and enough antibiotic to treat 20 million people for anthrax. In the event of an emergency, these vaccines would be delivered in push packages of emergency supplies to the Emergency Staging Area (ESA). Timely delivery and disbursement of adequate supplies at ESAs pose major logistical challenges, more so in high-density urban regions like Southern California.

**Objectives:**
The primary objective of this research is to develop a family of planning models that determine the location and distribution of inventoried items in response to a large scale emergency.

**Major Products and Customers:**
The major product is a tool that enables facility location and vehicle routing solver embedded in a GIS environment. This would be useful to planners working in the Departments of Emergency Preparedness at the regional and local levels and the Center for Disease Control.

**Interfaces to other CREATE Projects:**
This project will interface with the CREATE Bioterrorism Case Study, the Emergency Response project led by Richard Larson, and the project “Transportation Plan for Strategic National Stockpile (SNS) – Deployment Within Los Angeles County” led by David Belson.

**Interfaces to non-CREATE Projects:**
This project will interface with a project led by Randolph Hall on a “Collaborative to Improve Patient Flow through Efficient Service Delivery and Resource Utilization for Los Angeles County.”

**Technical Approach and Milestones:**
There exists research both on emergency system dynamics (such as the propagation of diseases and performance of vaccination strategies) and on distributions systems in non-emergency scenarios. However to date, this research has not been integrated in the form of distribution models.
systems for emergency situations. We plan to address this gap in the research community by developing emergency response planning models for the distribution of inventoried items. Our research will specifically focus on addressing the following interrelated questions in the context of an emergency:

- Where do you locally store supplies for emergencies, and what should be the supply levels at each location?
- What is the best strategy for disbursing supplies once an emergency has occurred?

At the heart of these questions there is a transportation network where the distribution of the inventoried supplies takes place. The question of where to set the storage facilities can be translated to a facility location problem within this supply network. The problem of disbursement of supplies can be posed as a vehicle routing problem on this network.

**Facility Location Problem**

- Complete Model Formulation (May 05)
- Complete Genetic Algorithm Solution Procedure (December 06)
- Benchmark Solution Procedure against theoretical bounds and other heuristics on sample problem instances (May 06)
- Integrate into GIS (August 06)
- Using model, integrate with economic activities to determine impact of different deployment strategies (YR 3)

**Vehicle Routing Problem**

- Complete Model Formulation -- October 2005
- Benchmark Solution Procedure against theoretical bounds and other heuristics on sample problem instances -- August 2006
- Using model, integrate with economic activities to determine impact of different deployment strategies -- 2007.
Project 14a: Agent Based Simulation for Disaster Rescue (Tambe)

DEFACTO is a simulation tool to help train incident commanders for a large-scale urban disaster.

**Modeling Area:** Risk Management  
**Principal Investigator:** Milind Tambe  
**Institution:** University of Southern California  
**Student Research Assistants:** Nathan Schurr, Madhuri Kottamraju, Pratik Patil

**Brief Description:**  
This modeling and simulation effort is developing a tool to improve on current methods for training fire departments’ incident commanders. DEFACTO will enable more extensive training without taking as many fire fighters off duty. DEFACTO’s collection of simulators driving the training scenarios will enable the training fires and situations to unfold in a more accurate manner. The fire fighters in the experiment coordinate amongst themselves and with the human incident commander. This tool further enhances training by adding a sense of realism and perspective so that incident commanders feel as if they are really there.

**Objectives:**  
The key objectives of this effort are to explore human-agent team interaction so as to improve training methods, and to develop a simulation tool that will enhance preparation of Incident Commanders.

**Major Products and Customers:**  
The DEFACTO simulation tool will be made available to the Los Angeles Fire Department (LAFD) and other training details.

**Interfaces to other CREATE Projects:**  
This effort will initiate a collaboration with the other risk management projects (Larson, Dessouky/Ordonez), to apply recent lessons learned in emergency response, and integrate with RAW.

**Interfaces to non-CREATE Projects:**  
This effort will continue to interface with the LAFD, and explore inquiries from local companies interested in further development, technology transfer and licensing. We will also explore interactions with games developers to enhance the user interface.

**Technical Approach:**  
We use a proxy based general framework for creating teams. We make use of the OGRE 3D engine. We use GIS maps create the simulated environment.

**Major Milestones and Dates:**  
2. Work with LAFD on actual training scenario to be simulated in next phase -- February 2006.  
3. Scale up simulation to handle up to 50 Fire Engines and a larger scenario -- March 2006  
Project 14b: Security in Multiagent Systems by Policy Randomization (Tambe)

This research explores techniques for enhancing security for multiagent systems using policy randomization.

Modeling Area: Risk Management
Principal Investigator: Milind Tambe
Institution: University of Southern California
Other Investigators: Fernando Ordonez
Student Research Assistants: Praveen Paruchuri

Brief Description:
Security in multiagent systems is commonly defined as the ability of the system to deal with intentional threats from other agents. Our research focuses on domains where such intentional threats are caused by unseen adversaries whose actions or payoffs are unknown, e.g., terrorists who may threaten ports or airports. In such domains, action randomization can effectively deteriorate an adversary's capability to predict and exploit an agent/agent team's actions. Unfortunately, little attention has been paid to intentional randomization of agents' policies in single-agent or decentralized partially observable Markov decision processes (POMDP) without significantly sacrificing rewards or breaking down coordination. We provide two key contributions to remedy this situation. First, we provide three novel algorithms, one based on a non-linear program and two based on linear programs (LP), to randomize single-agent policies, while attaining a certain level of expected reward. Second, we provide rolling down randomization (RDR), a new algorithm that efficiently generates randomized policies for decentralized POMDPs via the single-agent LP method.

Objectives:
The key objective is to develop a modeling framework for providing security for multiagent systems acting in hostile environments where the enemy is unknown/unseen.

Major Products and Customers:
The major product is a new framework for developing security based applications in uncertain environments. This framework will be useful to AI researchers as a study toolkit that generates randomized strategies in critical security applications. Being the first such toolkit, it can be used for comparing and evaluating various (mostly deterministic) strategies that are generated from other frameworks against our randomized strategies.

Interfaces to other CREATE Projects:
There is a strong potential for this toolkit to become a central policy generator in other projects where uncertainty and security are key issues.

Technical Approach:
Decision theoretic framework has become quite popular in agent/multiagent literature where quantitative analysis of the system is involved. Applications based on security typically need us to find the best possible plan to be followed. We therefore develop our security based toolkit for
single/multi agent systems using the MDP (Markovian decision processes) framework where no world uncertainty is involved and the distributed partially observable Markovian decision processes (POMDP) framework for multiagent teams acting in partially observable domains. The focus of this work is to develop algorithms that generate optimal randomized policies in the most efficient manner. We first developed brute force algorithms for MDP’s and then enhanced these algorithms using Linear Programming techniques to make them efficient. Once we achieved this objective for MDP’s, we developed the only algorithm that addresses the issue of randomization in Distributed POMDPs. Our algorithm for Distributed POMDP uses the randomization algorithm for MDP as its underlying routine. This effectively implies that as newer algorithms for randomization are developed for MDP’s, they would make our Distributed POMDP algorithm efficient.

**Major Milestones and Dates:**
1. Address issues on un-modeled adversaries -- February, 06
2. Research on developing framework where adversary model is known -- March, 06
3. Implement toolkit based on the Scotland Yard game -- May, 06
4. Complete issues related to both Modeled and Un-modeled adversaries -- September, 06
Project 15: Emergency Response Modeling (Larson)

This project builds on existing operations research models to develop a freely available, downloadable planning tool for municipal administrators to plan for response to large events in their communities.

**Modeling Area**: Risk Management  
**Principal Investigator**: Richard C. Larson  
**Institution**: Structured Decisions Corporation  
**Other Investigators**: James M. Tien  
**Student Research Assistants**: Michael Metzger

**Brief Description**:
SDC is developing a family of analytical planning models that incorporate personnel and equipment resource allocation during the response to a major unexpected event. The research focuses on decision models for emergency response, especially response to terrorist attacks and major acts of nature. The model being developed is appropriate for police and emergency medical first responders to deploy their resources over space and time. Building from our recently demonstrated PC-based Hypercube Queuing Model, we are now including the effects of a major emergency event in the urban area.

**Objectives**:
The key objective of this effort is the design, development, testing and dissemination of catastrophic event emergency response planning models.

**Major Products and Customers**:
The main product is a computer-based planning model. Others are publications and presentations at conferences and other events. The primary customers are municipal decision makers whose responsibility it is to create Preparedness and Response Plans to major events. The other ‘customers’ are applied researchers and students who are doing or who plan to do research in homeland security.

**Interfaces to other CREATE Projects**:
This project interfaces with the Risk Management project being conducted by USC’s Maged Dessouky and Fernando Ordonez.

**Interfaces to non-CREATE Projects**:
We will explore a relationship with MIT on building a decision support tool for Hurricane Preparedness and Response.

**Technical Approach**:
We use techniques of applied operations research, computer science, and relevant aspects of social science such as participant observation and focus groups. The major tasks planned include
1. Characterizing over space and time the ‘region affected’ by a major emergency event such as terrorist attack or act of nature, and translate this characterization into the Hypercube Model framework.

2. Creating and implementing algorithms for the first responders to dispatch a fraction of their resources into the ‘affected region’ and to re-position their remaining resources over the rest of the service region.

3. Utilizing the work of the New York City Rand Institute, move the mathematics and algorithms of award-winning Fire Deployment Relocation Model (FDRM) into the GUI and general modeling framework of this project, so that the final model is useful to fire department planners as well.

4. Demonstrating the model to planners practicing in first responders agencies, obtain their constructive feedback.

5. Finalizing the model and posting it on the Internet for free downloading.

**Major Milestones and Dates:**

1. Region Geometry -- July, 2005
2. Algorithms -- September, 2005
3. Fire Department Relocation Model -- February, 2006
4. Demonstration – March, 2006
Project 16a: Resource Allocation Based on Critical Infrastructure (Zimmerman)

This project is developing quantified indicators of critical infrastructure use, capacity, spatial distributional characteristics, and value as a basis for a risk-based resource allocation prioritization system to protect those infrastructures.

**Modeling Area:** Risk Analysis, Economic Analysis

**Case Studies Supported:** Resource Allocation

**Principal Investigator:** Rae Zimmerman

**Institution:** Robert F. Wagner Graduate School of Public Service, New York University

**Other Investigators:**
- Carlos E. Restrepo, Associate Research Scientist (NYU-Wagner)
- Dr. Zvia S. Naphtali, Research Scientist (NYU-Wagner)
- Professor Jeffrey S. Simonoff (NYU-Stern)
- Professor Michael R. Greenberg (Rutgers) (in 2006)

**Student Research Assistants:** Debra Sotelo, Renuka Vijayanathan, Marine Lericolais, Nicole Dooskin; Wendy E. Remington

**Brief Description:**
Critical infrastructures are potential targets of terrorism. Their value, location, and capacity to attract or concentrate user populations are important risk factor inputs to homeland security resource allocation decisions for states, urban areas, and other geographic entities. Interdependencies among critical infrastructures contribute to risk levels. Methods are being developed to quantify the density of infrastructure nodes, networks, usage levels, where users congregate and are potentially exposed, and where available, the value of infrastructure, supplementing techniques using distribution of residential and/or employee populations as a basis for resource allocation for homeland security.

**Objectives:**
This effort will identify criteria to characterize critical infrastructures with respect to spatial patterns of usage, capacity, and facilities; obtain databases for critical infrastructures and their attributes; and apply the criteria to databases as a means of prioritizing geographic areas with respect to vulnerability to terrorist attacks.

**Major Products and Customers:**
This work will result in transferable tool and applications consisting of quantified indicators of location, capacity and value. The overall output will be a methodology or tool for decision-makers and risk and economic modelers to quickly access infrastructure density data to set investment priorities as new databases appear and existing ones are updated or changed. The methodology will consist of (a) A set of measures of infrastructure concentration or density for detailed infrastructure sectors at the state and metropolitan area geographic levels (b) Indicators broadly applicable across different infrastructure types and locations, such as concentration or location quotients, and (c) Representative data tables for current years (d) Direct comparisons with actual allocations and formulations for allocation available from other studies.
Customers include students and decision-makers such as managers of infrastructure operations and security. Initial companies include utility providers and security managers in the telephone, transportation, and electric power industries.

**Interfaces to other CREATE Projects:**
This project expects to interact closely with the Risk-Based Resource Allocation case study projects, and researchers at the University of Wisconsin-Madison as well as resource allocation studies underway at USC.

**Interfaces to non-CREATE Projects:**
This work dovetails with work currently underway by another DHS funded academic center, the Institute for Information Infrastructure Protection (I3P) managed by Dartmouth College, which focuses on the use of Supervisory Control and Data Acquisition (SCADA) systems in the oil and gas industry. Interfaces with research underway in this area by other organizations is expected to occur, for example, with the Rand Corporation.

**Technical Approach:**
1. Identify criteria to characterize location, capacity, usage, and asset value (where available) of critical infrastructures.
2. Obtain and build databases initially at state and key metropolitan area levels adaptable ultimately to other geographic scales
3. Apply criteria (location, capacity, usage, and value) in areas such as transportation (roadway and vehicle capacity and usage; transit facilities and use), energy (pipelines, fuel storage and refinery facilities, energy production, transmission and distribution), water and wastewater, and telecommunications.
4. Develop and apply indicators of spatial and functional concentration to the critical infrastructure databases in order to identify areas of concentration and develop a tool that others can use. Two computations in particular will be applied to data: (a) location quotients that capture the concentration of facilities and activity relative to some base such as population or employment, and (b) concentration ratios typically used to measure industrial activity. These measures have been used traditionally for many decades to portray the spatial characteristics of industrial activity, and the unique feature of this research is the application of these measures to critical infrastructure.

**Major Milestones and Dates:**
1. Identify, assemble, and begin to spreadsheet representative databases for infrastructure characteristics -- Summer 2005
2. Begin to produce descriptive graphs and maps as appropriate to target areas for concentrated research and for communication of information, and begin statistical analysis of data -- Fall 2005.
3. Develop indicators of concentrated location, capacity, usage, and value -- Winter 2006.
4. Apply indicators of concentration to critical infrastructure databases; conduct statistical analyses of data to determine time trends in concentration characteristics -- Spring 2006.
Project 16b: Critical Infrastructure for Border Security (Zimmerman)

This work is estimating the role of infrastructure in the vulnerability of border crossings to terrorist attack, and the severity of consequences of such attacks attributable to infrastructure.

**Modeling Area:** Risk Analysis  
**Case Studies Supported:** Border Security  
**Principal Investigator:** Rae Zimmerman  
**Institution:** Robert F. Wagner Graduate School of Public Service, New York University  
**Other Investigators:** Carlos E. Restrepo, Associate Research Scientist (NYU-Wagner), Dr. Zvia Naphtali, Research Scientist (NYU-Wagner), Professor Jeffrey S. Simonoff (NYU-Stern)  
**Student Research Assistants:** Debra Sotelo, Renuka Vijayanathan, Marine Lericolais; Wendy E. Remington

**Brief Description:**  
U.S. borders are a high priority for homeland security, given their connection to economic activity for international and domestic trade. Electric power, telecommunications, and other infrastructure are a hidden dimension not only supporting transportation’s direct role in people, goods and services movement across U.S. borders, but also providing direct cross-border transfers of the goods and services these infrastructures provide. The role of these critical infrastructures for border security has not been systematically studied, and this project provides an approach to identify and prioritize infrastructure systems that supports border security, using a limited number of ports, that potentially can be applied to many different kinds of ports.

**Objectives:**  
The objective of this research is to develop the means to portray infrastructure’s role in border security on the basis of its interconnectivity with border activities and functions, in order to establish risks of terrorist attacks at border areas by means of attack on infrastructures upon which these border areas depend.

**Major Products and Customers:**  
This project will develop a tool consisting of indicators and ways to use databases for assessing infrastructure’s role in border security. This tool is comprised of a screening process and means to identify border dependency on infrastructure. Its customers are students and decision-makers such as managers of border operations and security. Specific customers expected to be involved in the project include the Port Authority of NY and NJ and port agencies from other ports selected for in-depth study.

**Interfaces to other CREATE Projects:**  
This project will interact closely with the Border Security Case Study and researchers at USC.
Interfaces to non-CREATE Projects:
Interfaces with other port projects underway are expected as the project proceeds.

Technical Approach:
- Develop criteria to prioritize border crossings for more in-depth study and as inputs for risk and consequence assessment for selected ports. These criteria are expressed in terms of risk factors and measures reflecting vulnerabilities unique to infrastructures at border crossings. Some examples of such criteria are (i) importance of the role in sustaining border activity, (ii) volume of activity, (iii) infrastructure asset value, (iv) value of commodities shipped, and (v) uniqueness (non-redundant configurations).
- Screen border crossings according to criteria related to the importance of infrastructure in supporting the viability of these borders.
- For selected crossings and key infrastructures at those crossings, identify infrastructure facilities and activity for more detailed study.
- Characterize key infrastructure vulnerabilities in the context of an attack (based on or in terms of factors that include criteria above), netting out security measures now in place.
- Include the role of critical infrastructure interdependencies as contributors to vulnerability and as a basis for prioritizing those vulnerabilities.
- Develop a set of scenarios that reflect the impact of hypothetical attacks on border infrastructure.
- Use catastrophic events that have affected port areas as prototypes to understand role and effect upon interconnected infrastructure. Included in port case studies will be a case study of the interconnectivity of critical infrastructures with port operations in the Gulf Coast, and the effect that Hurricane Katrina had on these operations. The Port of South Louisiana ranks first in the nation in tonnage of cargo throughput. Although this was not a terrorist attack, the case exemplifies what could happen in a very wide area attack on port infrastructure.

Major Milestones and Dates:
1. Identify types of U.S. border crossings -- Spring 2005.
2. Begin to identify selected characteristics of infrastructure, including infrastructure components at typical borders -- Summer 2005.
3. Develop criteria for importance of infrastructure for border functions; initial work will be conducted using airport databases -- Fall 2005.
4. Screen/select a set of border crossings for in depth study; Identify infrastructure at selected border crossings, document screening process, and include measures of border dependency on infrastructure; Develop scenarios for hypothetical attacks on border infrastructure for selected area(s); Develop transferable tool to decision-makers and students -- Spring 2006.
Project 17: Strategic Decision Making in Presence of Adversaries (Hall)

This research is developing a new methodology for strategic decision making under uncertainty and presence of adversaries.

**Modeling Area:** Risk Management

**Case Study:** MANPADS, Bioterrorism

**Principal Investigator:** Randolph Hall

**Institution:** University of Southern California

**Student Research Assistants:** Erim Kardes

**Brief Description:**
This investigation is motivated by the need to determine optimal strategies under uncertainty against an adversarial and adaptive opponent, such as arise in the context of terrorism threats. To model investment decisions that pertain to homeland security, one should account for both uncertainty and the antagonistic character inherent in the problem. We propose a novel approach, robust stochastic games. We focus on incomplete information stochastic games and adopt a robust approach to account for uncertainty present in our problem in two dimensions.

**Objectives:**
The objective of this research is to develop a methodology for risk analysis in the presence of adaptive adversaries using a formulation based on robust stochastic games. The near term objective is to demonstrate the existence of equilibrium points, and apply to bioterrorism.

**Major Products and Customers:**
The major product of this research is a novel methodology for risk analysis, and a case study analysis to evaluate its effectiveness and assess its characteristics versus other risk analysis tools.

**Interfaces to other CREATE Projects**
This effort will interface with the MANPADS and bioterrorism case studies and in the longer term with RAW.

**Technical Approach:**
First, we consider that the adaptive nature of the adversary is uncertain. In other words, we propose a new approach that accounts for the uncertainty in the conversion from one threat category to the other that is based on the alternatives of the adversaries. Second, we consider that payoffs to the opponents are uncertain. We present an interesting new result, existence of equilibrium points in robust stochastic games. A new formulation that uses robust optimization techniques is proposed to solve robust stochastic games. Preliminary results are presented on a simple example with partial unknown data. This research includes the development of the model for the bioterrorism case study, quantification of the model via expert elicitation, and computation of robust optimal strategies.
Major Milestones and Dates:
- Existence of equilibrium has been shown and a sample equilibrium calculation is achieved on a small numerical example.
- Formulation of robust stochastic game for the aviation model -- Fall 2005.
- Data collection -- Summer 2005.
- Solution methodology for the model -- Fall 2006.
- Final report -- Fall 2006.
Project 18: Bioterrorism Case Study (von Winterfeldt and O'Sullivan)

This project is developing new methods for assessing bioterrorism risks and evaluate policies for reducing the risks and consequences of bioterrorism attacks.

**Modeling Area:** Risk Management  
**Principal Investigator:** Detlof von Winterfeldt  
**Institution:** University of Southern California  
**Other Investigators:** Richard S. John, Terry O’Sullivan  
**Student Investigators:** Heather Rosoff

**Brief Description:**  
This project consists of several related activities for assessing the risks of bioterrorist attacks and for evaluating policies to reduce risks and consequences of such attacks. A major part of this project consists of developing tools for assessing terrorists’ motivations and capabilities regarding the use of biological agents. Building on and collaborating with ongoing risk assessments at the National Biodefense Analysis and Countermeasures Center (NBACC) we will develop influence diagram tools and assess terrorists’ motivation and capabilities for five high-threat biological agents. We will also conduct a project risk analysis of an anthrax attack, similar to the one conducted previously for a dirty bomb attack. Furthermore, we will assist NBACC in the review and development of their risk assessment and economic analysis tools.

**Objectives and Technical Approach:**  
This research will develop advanced methods for assessing the risks of biological attacks. We will use influence diagram techniques and probabilistic choice models to assess the terrorists’ assessment of the utility of using selected biological agents. This is an important input to assessing the probability that terrorists would select one of these agents. We will continue our project risk analysis approach to assess probabilities of success, if a terrorist groups selects a particular agent, for example, anthrax.

**Interfaces to other CREATE Projects:**  
This work will maintain a close collaboration with the risk analysis and economics projects. The projects on emergency planning for medical supplies will provide the major link to assessing policies for reducing consequences of biological attacks.

**Interfaces to non-CREATE Projects:**  
The consequence modeling will largely be done in interactions with the NBACC risk assessment groups at Battelle Memorial Institute and at Sandia National Laboratories. Other collaborations are with the California Department of Health Services to assess the costs and benefits of the Biowatch program and with the County and City of Los Angeles to improve medical supply storage and distribution. This project will also interact with FAZD Center; Minnesota Center for Food Protection and the START Center.
Major Products and Customers:
Customers: NBACC - Risk and economic assessments; California Department of Health Services - Assessment of the Biowatch program; LA County and City - medical supply storage and distribution.
Products: Models of terrorists’ motivations and capabilities for biological attacks; project risk analysis models of an anthrax attack; models to optimize locations and distribution of medical supplies; cost-benefit analysis of the Biowatch program.

Major Milestones and Dates:
• O’Sullivan report on smallpox attacks -- June 2005.
• Preliminary models of terrorist’s motivations and capabilities regarding 5 biological agents -- January, 2006.
• Preliminary project risk model for anthrax -- February, 2006.
• Models for optimizing locations and delivery of medical supplies -- March 2006.
• Reports on the models describes above -- June 2006.
Project 19: Border Security Case Study (Maya and Bakir)

This Case Study seeks to develop and apply systems-based risk management methodology for evaluating alternative policies and technology-based solutions for protecting our borders against illegal importation of weapons, terrorist infiltration and direct terrorist attacks while maintaining the free flow of trade.

**Modeling Area:** Risk Management  
**Principal Investigator:** Isaac Maya  
**Institution:** University of Southern California  
**Other Investigators:** N. Onur Bakir

**Brief Description:**  
The scope of this Case Study covers maritime, land border and aviation security. We will develop and apply a systems-based risk management approach that performs comparative risk assessment between different elements of integrated border security operations to support fund allocation decisions. It will include a comprehensive overview of threats and vulnerabilities. We will examine alternative security strategies, including methodologies for screening and inspecting cargo, and operational improvements that promote participation in trusted shipper programs. We will provide a comprehensive examination of the alternative methods for shipping goods into the United States, and a comparison of technology-based solutions to deter and detect terrorists and weapons crossing the borders.

**Objectives:**  
- Identifying threats and vulnerabilities that constitute the terrorism risk exposure of the border security system.  
- Development of a methodology to perform comparative risk assessment between elements of border security.  
- Evaluation of alternative policies and technology based solutions to protect the borders from weapons smuggling, terrorist infiltration and direct attacks on infrastructure.  
- Measuring sensitivity of policy decisions on probability and potential consequences of a particular component failure.  
- Provide insights into funding allocation decisions for border security.

**Major Products and Customers:**  
This project will develop a methodological tool for comparative risk assessment between components of the border security system. We will select “cargo security” as our initial case study and develop a software tool to evaluate alternative investments and policies to improve cargo security. The results will be documented in a comprehensive report. Major customers are the policy analysts responsible for border security, for example, the Customs and Border Protection (CBP) Department, and the Office of the Private Sector and Science & Technology Directorate under DHS. At the regional and local levels, customers include the Office of Homeland Security in California, the LA/LB port complex officials.
Interfaces to other CREATE Projects:
The border security project will have close interface with the Bioterrorism and Resource Allocation Case Studies.

Interfaces to non-CREATE Projects:
The LA/LB Joint Container Inspection Facility (JCIF) potential project could be a good case study extension for the maritime cargo security component of the border security project. The interplay between these projects is more visible because we may apply the methodology developed in the border security project on evaluation of technology in container inspections.

Technical Approach:
The main objective of border security is to minimize casualties and economic losses due to terrorism while ensuring flow of commerce, continuity of business, conserving environment and supporting international partnerships for research, development and education. Countermeasures to reduce terrorism risk are in the form of either technology based investments or policies. We will follow the steps below,
1. Data collection and model development: We will locate and access data that will quantify terrorism risk, potential consequences of a terrorist attack due to failure of each component, risk reduction both in terms of reduction probability of failure and potential consequences when a countermeasure is implemented as well as cost of each countermeasure. We will collect data and develop the model simultaneously.
2. Evaluation of selected countermeasures and sensitivity analysis: In this phase, we will use the data in our model to evaluate countermeasures. We recognize at this stage that resources allocated on each component collectively determine the overall terrorism risk profile. Marginal value of each countermeasure is measured in terms of terrorism risk reduction on multiple components. At this stage, we will do a sensitivity analysis to observe how policy decisions change based on a range of probability or consequence estimates.
3. Ranking of countermeasures: Analysis of results will provide us ranking among different countermeasures and help us determine which countermeasures should be implemented given financial constraints.
4. Review of recommendations: Based on the results in Phase 3, we will determine our recommendations. These recommendations will be reviewed with the experts on border security.
5. Conclusions and final report

Major Milestones and Dates:
The major milestones for the border security project include
1. Initial results from the case study and preparation of the fourth draft of the report, Complete data collection and model development -- March 2006.
5. A final report on both the case study and the border security project -- August 2006.
Project 20: Risk-Based Resource Allocation Case Study (Kleinmuntz and Quadrofiglio)

This project is developing new methods for improving the allocation of resources to alternative programs for reducing the risks and vulnerabilities to terrorist attacks.

Modeling Area: Risk Analysis  
Case Studies Supported: Risk-Based Allocation  
Principal Investigator: Don Kleinmuntz  
Institution:  University of Illinois, Urbana-Champaign  
Other Investigators: Detlof von Winterfeldt, Luca Quadrofiglio

Brief Description:  
This project will use existing software tools and develop improved methodologies for the allocation of funds to programs and projects based on the ability of these programs and projects to reduce terrorism's risks and consequences. One major area is the allocation of DHS grants to States to improve the capabilities of first responders to deal with terrorist events.

Objectives:  
This research will develop advanced decision analysis methods to improve resource allocations. Building on several years of resource allocation models, this project will use an existing resource allocation model and computer tool to guide resource allocations. A main task is to quantify the effectiveness of risk or consequence reduction for alternative programs or projects. We will also explore a new methodology for defining a cost function for protecting targets.

Interfaces to other CREATE Projects:  
This work will maintain a close interface with the risk analysis and economics projects.

Interfaces to non-CREATE Projects:  
We are working with the Infrastructure Protection division of the DHS to use their RAMCAP methodology for prioritizing risks, and with the California Office of Homeland Security to implement a pilot study to prioritize California sites in terms of risks and risk reductions. We also plan to collaborate with Lawrence Livermore National Laboratories’ HOPS program to provide risk assessments.

Major Products and Customers:  
Customers: DHS – IP; DHS – ORD; California OHS  
Products: Risk assessment methodology for prioritizing projects and programs and to gauge the cost/effectiveness of investments in risk reductions; Software implementation of these methodologies; Research publications and reports.

Technical Approach:  
- Survey resource allocation approaches and models  
- Collect information on selected California targets and perform a Likelihood and Consequence assessments of terrorist attacks for each target $i$.  

Optimal Allocation to Minimize Risks
• Design risk assessment and allocation methodology for selected set of sites in California.
• Definition and development of a “cost function” $c_i(\$)$ for each target $i$, representing the expected consequences due to terrorist attacks, as a function of the funds $\$_i$ invested to mitigate them.
• Development of an optimal allocation methodology among the entire set of targets to minimize the total expected consequences $\sum_i c_i(\$_i)$, subject to the constraint $\sum_i \$_i = \$_{TOT}$,
• where $\$_{TOT}$ represents the total available funds.
• Conduct pilot study for prioritizing California sites and allocating investments to reduce risk at these sites.
• Generalization of the methodology to be applied at other decision levels, such as the funding allocation of federal funds among States.

**Major Milestones and Dates:**
3. Develop risk and consequence measures to reflect the impact of terrorism events and a multidimensional risk index that combines these diverse risk and consequence measures based on policy makers’ judgments about the relative severity of consequences -- March 2006.
4. Completion of pilot study for prioritizing California sites and for allocating investments to reduce risk at these sites -- April 2005.
5. Incorporate the risk reduction measures into a risk allocation model that takes into account both the effectiveness of various alternatives and their cost -- June 2005.
6. Reports on the models and implementation described above -- June 2005.
8. Explore extensions of model to account for continuous expenditure levels -- October 2006.
Appendix D

Course Syllabi

Course Syllabus: PPD 587

Risk Analysis (4 Units)

Catalogue Description

Concepts of risk analysis, risks in engineered systems, environmental risks, security risks; methods of risk analysis, fault trees and event trees; quantification of probabilities, use of data, models, and expert judgments; risks and decisions, interlinking risk analysis with risk management; applications to homeland security decisions.

Recommended preparation: MATH 108 or MATH 116

Instructor - Detlof von Winterfeldt

Office: RGL 312D
Office Hours: Tuesdays 5-6 PM
Telephone: (213) 740 4012
e-mail: detlof@aol.com

Class Time and Location

Class Time: Tuesdays 6:30 to 9:30 PM
Additional time for project discussions will be scheduled separately
Location: DEN Classroom

Textbooks


Additional Reading


Overview

This class is an introduction to risk analysis in several fields, including engineering risk analysis, environmental risk analysis, and security risk analysis. Many examples will come from the homeland security area in connection with work that is being conducted at USC’s Homeland Security Center for Risk and Economic Analysis of Terrorism Events. Students will be introduced the concepts and methods of risk analysis and to software tools and procedures that help the implementation of risk analysis. Students will also learn how to apply risk analysis in real world settings.

Objectives

- Understand the basic concepts of risk analysis and the relationship between probability theory and modeling, risk analysis, and decision analysis
- Understand how to use probability, probabilistic modeling and probabilistic simulation for risk analysis
- Learn how to use the basic tools of risk analysis – fault trees, event trees, simulation models, and influence diagrams
- Learn how to use expert judgment in risk analysis
- Understand the issues of using risk analysis in decision making, especially in regulatory settings

Class Format

The class will be primarily in a lecture format. In addition, students will conduct a simple risk analysis project of their own choice and present progress reports throughout the class. The last class will be devoted to final presentations of the projects. Off-campus students should submit annotated or voiced-over PowerPoint files in lieu of progress reports. All students are encouraged to be on campus for the final presentations on April 26. If this is not possible, an annotated or voiced over PowerPoint presentation needs to be submitted in lieu of the final presentation. All students will submit a final report due one week after the final presentation.

Tests and Grades

Grades will be assigned on the basis of class and bulletin board participation (20%), the quality of the four project presentations (10% each for a total of 40%) and the final report (40%).
Disability Services and Programs Statement

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to the TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. – 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Detlof von Winterfeldt - Biosketch

Detlof von Winterfeldt is the Deputy Dean of the School of Policy, Planning, and Development at the University of Southern California, Professor of Public Policy and Management, and co-director of USC’s Homeland Security Center for Risk and Economic Analysis of Terrorist Events. For the past twenty-five years, he has been active in teaching, research, university administration, and consulting. He has taught courses in statistics, decision analysis, risk analysis, and human judgment and decision-making. His research interests are in the foundation and practice of decision and risk analysis as applied to technology, environmental, and terrorism problems. He is the co-author of two books and author or co-author of over one hundred articles and reports on these topics. His administrative experiences include serving as Director of USC’s Institute for Civic Enterprise, chairman of USC’s Systems Science Department and chairman of the Research Center at the Institute of Safety and Systems Management. As a consultant he has applied decision and risk analysis to many management problems of government and private industry. He has served on several committees and panels of the National Science Foundation (NSF) and the National Research Council (NRC), including the NSF’s Advisory Panel for its Decision and Risk Management Science Program, the NRC’s Committee on Risk Perception and Risk Communication, and, most recently, the NRC’s Board on Mathematical Sciences and their Applications. In 2000, the Decision Analysis Society awarded Dr. von Winterfeldt the Ramsey Medal for distinguished contributions to decision analysis. He is a fellow of the Society for Risk Analysis and of the Institute for Operations Research and Management Science (INFORMS).

Schedule - Risk Analysis PPD 587

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<th>Week</th>
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<th>Topics</th>
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<tr>
<td>1</td>
<td>1/11/2005</td>
<td>Introduction and overview of class; definition of risk; overview of risk analysis; three examples</td>
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<td>2</td>
<td>1/18/2005</td>
<td>Getting started: Identifying and structuring risk problems; developing a deterministic or parametric model</td>
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<td>3</td>
<td>1/25/2005</td>
<td>Uncertainty, probability, and risk; review of probability and statistics for risk analysis. <strong>First presentation: Three projects</strong></td>
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<td>4</td>
<td>2/1/2005</td>
<td>Continued review of probability and statistics for risk analysis; classical and Bayesian statistics</td>
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<td>5</td>
<td>2/8/2005</td>
<td>How to obtain probabilities from experts; examples of major expert elicitation exercises</td>
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Readings

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<td>4/19/2005</td>
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<td>16</td>
<td>4/26/2005</td>
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1 B&C: Bedford and Cooke; K&H: Kammen and Hassenzahl; italized chapters are optional reading.
2 Items in bold refer to student presentations; DEN students will send annotated or voiced-over Powerpoint slides.
Course Purpose and Objectives

This course is designed to provide students with an understanding of how public organizations may deal with the threat of various forms of terrorism. A student who successfully embraces the teachings offered by this course will be able to:

1. Develop a working definition of the term “terrorism” and apply it to public policy decisions.
2. Understand the organizational challenges and shared federal, state and local government responsibilities facing the Department of Homeland Security.
3. Examine the critical balance of effective national security and basic civil liberties at a time when America is at risk to a new and changing threat.
4. Apply the practice of interdependent security in developing comprehensive protection plans and policies designed to reduce the vulnerability to deliberate violent acts.

Course Overview

Maintaining public safety and security are basic functions of government. The events of September 11, 2001, have resulted in the realization that our government must change in response to new and evolving threats. The most dramatic response was the creation of the Department of Homeland Security, whose strategic objectives are to prevent terrorist attacks within the United States, reduce America’s vulnerability to terrorism and minimize the damage and recover from attacks that do occur. The United States has always overcome incredible homeland obstacles, as exemplified by the outcomes of the Revolutionary and Civil Wars. Resilience, focus and America’s diverse talents have contributed to our survival. The mission of Homeland Security, however daunting, must be addressed with the same resolve.

Required Texts

You may purchase the following three publications at the USC Bookstore.


In addition to the three publications listed, copies of the Public Administration Review (PAR), Volume 62, Special Issue of September 2002 on responses to terrorism, will be distributed on the first day of class.

Course Requirements

This course will be taught as a seminar, with readings, papers and presentations by students and guest speakers drawn from the various agencies and specialties involved in the Homeland Security effort. Inasmuch as one of the goals of the course is to prepare the student for the rigors of addressing homeland security policy issues, class participation in the weekly discussions and most notably in the Class Exercise is critical. There will be a midterm and a final examination.

The policy memorandum, due Week 9, will be a 3 – 5 page recommendation from the student, acting as the Interim Secretary of Homeland Security, to the President of the United States and the National Security Advisor. After attending briefings from the appropriate agencies, it has been determined that a credible threat exists, detailing a series of attacks in the United States, to be committed by a homegrown, multi-ethnic, interdenominational coalition. The memo should articulate a recommended response, considering such issues as organizational/departmental balance, costs, planning and the effect, if any, on the nation’s focus on international terrorism.

The policy paper, due Week 12, will be a 10 – 12 page in-depth study of a homeland security policy challenge of your choosing that will require the application of the materials studied and presented in this course. Students should choose their topic for in-depth policy paper by the fifth class meeting. Policy papers will be due at the twelfth class meeting. The policy paper must include citations to at least 10 books or journal articles, including the course books and/or lectures, as appropriate.

Please note that all papers are to be of professional quality in both content and composition. Correct English, clear organization and a logical presentation format are crucial. Text should be in 12-point font and double-spaced. Please do not put papers into binders. Simply include your name and course title on first page of each paper and all pages are to be stapled.

The City Council Exercise will be one of the culminating events for this course. The class will be divided into several agencies, e.g. the FBI, police department, ACLU, city council members, department heads, etc., and each provided the appropriate information to function in their designated capacities. The city will be faced with a terrorist threat that allows limited research and debate, but must result in a public policy proposal for consideration by the city council. The scenario does not include the luxury of time. Students will be expected to utilize information presented and discussed throughout the course in support of their respective positions.

Evaluation of Performance

The expectation is that this course will provide knowledge that will assist in your ability to perform well as a professional. Facilitation of success is a principal function of an organization and of managers. The instructor places no higher priority on this issue in presenting this course and would expect you to do the same. Your performance will be evaluated as follows:

1. Class Exercise 10%
2. Policy Memorandum 10%
3. Midterm Examination 20%
4. Policy Paper 30%
5. Final Examination 30%
## Course Schedule and Readings

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<tr>
<th>Week</th>
<th>Subject &amp; Readings</th>
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| 1    | Course overview and the Department of Homeland Security  
*Description:* We will discuss class expectations from the course and examine some of the major policy and strategic challenges facing the Department of Homeland Security and our national security. |
| 2    | The Roots of September 11  
*Description:* This week we will examine the development of contemporary terrorism, terrorist strategy, terrorism in the Middle East, globalization Nativism and anti-Semitism.  
*Readings:* The 9/11 Commission Report: Ch. 1 “We Have Some Plans” (pp. 1-46), Ch. 5 “Al Qaeda Aims At The American Homeland” (pp. 145-173) |
| 3    | The History of Terrorism  
*Description:* We will examine the history of terrorism from several perspectives including, religious terrorism, state-sponsored terrorism, political terrorism, and terrorism and nationalism.  
*Readings:* Griset & Mahon: Ch. 1 “History of Terrorism” (pp. 1-44)  
The 9/11 Commission Report: Ch. 2 “The Foundation of The New Terrorism” (pp. 47-70) |
| 4    | The Definition of Terrorism  
*Description:* We will discuss a myriad of definitions of terrorism and the associated foreign policy challenges. We will examine terrorism as compared to revolutionary violence and national liberation; conventional vs. non-conventional conflict and guerrilla warfare.  
*Readings:* White: Ch. 1 “Mutating Forms of Terrorism” (pp. 3-17), Ch. 2 “Individual and Group Behavior” (pp. 18-30) |
| 5    | International Terrorism  
*Policy paper topic selection due this class session*  
*Description:* We will review the definition of international terrorism, terrorism around the world, famous terrorists and the examination of a terrorist target selection model. We will also discuss the future and legitimacy of preemptive strikes and its use as a counterterrorism strategy.  
*Readings:* Griset & Mahon: Ch. 2 “International Terrorism” (pp. 45-83)  
The 9/11 Commission Report: Ch. 6 “From Threat to Threat” (pp. 174-214) |
| The Homegrown Threat  
*Description:* We will examine state-sponsored terrorism, particularly as it relates to the U.S. and the history of Native Americans. We will also explore the ideology of left class struggles, anarchists, Ecoterrorists, racial supremacists and religious extremists in America.  
*Readings:* Griset & Mahon: Ch. 3 “Homegrown Terrorism in the United States (pp. 85-128)  
White: Ch. 13 “Terrorism in the United States” (pp. 204-219), Ch. 14 “Violent Extremism in the United States” (pp. 220-236) |
| 4    | Suicide Terrorism  
*Midterm Examination will be held this class session.*  
*Description:* We will attempt to look inside the mind of a suicide bomber by reviewing Santosh Sivan’s film, The Terrorist. We will examine the modern history and globalization of suicide bombing from the Iran-Iraq war, Lebanon and Hezbollah, the Israeli-occupied Palestinian land, and the regions of Sri Lanka, Chechnya and Kurdistan. |
5 The Federal Response: Organizational Structure

*Class Exercise will be held this class session.*

**Description:** This class will include an in-depth examination of our National Strategy of counterterrorism and the history of our nation’s diverse organizational responses to this challenge.

**Readings:** The 9/11 Commission Report: Ch. 3 “Counterterrorism Evolves” (pp. 71-107), Ch. 4 “Responses To Al Qaeda’s Initial Assaults” (pp. 108-143)


6 Counterterrorism Strategy and Planning

*Policy memorandum due this class session.*

**Description:** We will review counterterrorism and domestic policy, including some of the more noteworthy FBI investigations including, the Los Angeles 8, Amnesty International, Library Awareness Program, ACT-UP, Earth First and Lance Lindblom.

**Readings:** Griset & Mahon: Ch. 8 “Counterterrorism” (pp. 277-311)

Newland: *The Fundamentals of Terrorism and Its Target: Responsible Government*

The 9/11 Commission Report: Ch. 12 “What To Do? A Global Strategy (pp. 361-398)

7 Intelligence and Risk Analysis

**Description:** We will examine the United States intelligence agencies, the history of these agencies, their respective specification of functions and the application of Game Theory to threat and risk analysis.

**Readings:** The 9/11 Commission Report: Ch. 8 “The System Was Blinking Red” (pp. 254-277), Ch. 13 “How to Do It? A Different Way Of Organizing the Government” (pp. 399-428)

8 The Role of the FBI

**Description:** This session will examine the historical relationship between Presidents, Congress and the FBI, FBI authority, mechanisms for control and their enhanced intelligence role in counterterrorism.

**Readings:** Cole & Dempsey: Ch. 5 “Mechanisms for Control of the FBI” (pp. 65-70), Ch. 6 “Seventy-Five Years of Reform and Retrenchment” (pp. 71-89), Ch. 7 “Constitutional Limits – The Role of the Judiciary” (pp. 91-103)

Haque: *Government Responses to Terrorism: Critical Views of Their Impacts on People and Public Administration*

9 Civil Liberties and the War on Terrorism

*Policy paper due this class session.*

**Description:** This class will examine the repeated legislative mistakes our country has made during other wartime eras regarding national security and civil liberties. We will also discuss the impact of the 1996 and 2001 Antiterrorism Acts and the costs to society beyond the possible reduction of civil liberties.

**Readings:** Cole & Dempsey: Ch. 8 “Prologue to the 1996 Antiterrorism Act (pp. 107-115), Ch. 9 “The 1996 Antiterrorism Act’s Central Provisions (pp. 117-126), Ch. 10 “The Impact of the 1996 Act” (pp. 127-146), Ch. 11 “Fighting A War Against Terrorism at Home and Abroad” (pp. 147-175)

10 The Challenges of Public Sector Management

**Description:** We will examine new measures of the war on terrorism, the impact on people’s rights and public administration, interdependent security and the implications for homeland security policy.

**Readings:** Walker: *9/11: The Implications for Public Sector Management*

White: Ch. 17 “Policy, Liberty, Security and the Future” (pp.267-283)
11 Final Examination

Academic Integrity

Please review the USC statement of academic integrity carefully.

Students with Disabilities

Any student requiring academic accommodation based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure that the letter is delivered to the course professor early in the semester, prior to the first day of class. DSP is located in STU 301 and is open 8:30 a.m. to 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Instructor’s Brief Resume

Erroll G. Southers is the Deputy Director of the California Office of Homeland Security, appointed by Governor Schwarzenegger and responsible for the state’s critical infrastructure protection. He is a member of the USC Center for Risk and Economic Analysis of Terrorist Events (CREATE) Government Advisory Board and a Senior Fellow in the UCLA School of Public Affairs. Mr. Southers is a former FBI Special Agent assigned to matters of counterterrorism, foreign counterintelligence, and was a member of the Bureau’s SWAT Team. A former Santa Monica Police Department detective and member of the Rio Hondo Police Academy faculty and tactical staff, he is also a court-qualified gang expert. During his tenure as the Assistant Vice President of Visitor Services at the Los Angeles County Museum of Art, he managed more than 200 security personnel and served as the museum’s Chief of Protective Services and Department Emergency Coordinator. Mr. Southers is a Certified Institutional Protection Manager and founded Risk Management Consultants International, a security consulting firm specializing in violence prevention, premises protection and emergency preparedness. His clients include academic and cultural institutions and programs across the country. As an Executive Director for the City Manager in Long Beach, Mr. Southers was responsible for the oversight of the investigation of allegations of police misconduct and successfully managed a truce between the City’s Latino and Cambodian gangs. Mr. Southers earned his bachelors degree at Brown University and his MPA at the University of Southern California.
SHORT-COURSE ON
COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

Professor Adam Rose
Penn State University

Week of October 17, 2005
Campus of University of Southern California

Session 1.  Input-Output Review; Social Accounting Matrices;
Introduction to CGE Analysis

Session 2.  Math Programming & GAMs;
CGE Modeling Basics

Session 3.  CGE Complications, Applications
& Programming

READING LIST FOR SHORT COURSE
ON COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

Adam Rose
Penn State University
October 2005

I.  INPUT-OUTPUT ANALYSIS AND SOCIAL ACCOUNTING MATRICES


II. MULTI-SECTOR PROGRAMMING


III. BASIC THEORY OF COMPUTABLE GENERAL EQUILIBRIUM MODELS


Dervis et al., Ch. 5.


IV. CGE MODEL CONSTRUCTION AND BASIC APPLICATIONS

Shoven, J. and J. Whalley, Chs. 5, 6, 8, & 9.


Dervis et al., Chs. 6 & 7.


V. APPLICATIONS TO NATURAL HAZARDS AND TERRORISM


Appendix E

Agendas for CREATE Conferences and Workshops

This appendix provides tables containing the agendas for the nine conferences and workshops conducted by CREATE.
Table E-1. Economic Costs and Consequences of a Terrorist Attack, August, 2004

Welcome Detlof von Winterfeldt, University of Southern California
“Interdependent Security” Howard Kunreuther, University of Pennsylvania
“Transnational Terrorism: An Economic Analysis” Todd Sandler, University of Southern California Walter Enders, University of Alabama
“Increasing the Security and Reliability of the USA Electricity System” Lester Lave, Jay Apt and Granger Morgan, Carnegie Mellon University
“Current and Improved Biodefense Benefit-Cost Assessment” Clark C. Abt, Abt Associates Inc.
“Land Markets & Terrorism: Uncovering Perceptions of Risk by Examining House Price Changes Following 9/11” Christian L. Redfearn, University of Southern California
“The Transportation Implications of a Terrorist Attack on Seattle’s Bridges” Christine Bae, University of Washington and Larry Blain, Puget Sound
“An Experimental Investigation into the Economic Efficiency Gains for a Spatially Distributed Homeland Alert System” Phillip Ganderton, David S. Brookshire, University of New Mexico and Richard Bernknopf, US Geological Survey
“Asessing Port Security Programs and Identifying Gaps in Coverage” Jon D. Haveman and Howard Shatz, Public Policy Institute of California
“Mitigation of Extreme Event Risk: Electric Power Outage and Cascading Effects” Stephanie Chang, Timothy McDaniels and Dorothy Reed, University of British Columbia
“Analyzing Terrorist Threats to the Economy: A Computable Equilibrium Approach” by Adam Rose, Pennsylvania State University
“The Economic Impact of a Terrorist Attack on the Twin Ports of Los Angeles-Long Beach” Peter Gordon, J. Moore, H.W. Richardson, Sunbin Cho, Soojung Kim and Mayank Mohan, University of Southern California and Qisheng Pan, Texas Southern University

Table E-2. CREATE Conference on Reducing the Risks and Consequences of Terrorism, November 2004

Keynote Talk, Bureau Chief John Miller, Critical Incident Management Bureau, Los Angeles Police Department
Terrorism Risk Analysis: An Overview and a Dirty Bomb Example, Detlof von Winterfeldt, USC School of Policy, Planning & Development
Assessing the Likelihood of Terrorist Attacks: Case Studies in Bioterrorism & Airline Security, Terry O’Sullivan, USC Viterbi School of Engineering
Protecting Critical Infrastructure from Terrorism: A Risk-Based Multi-Hazard Approach to Vulnerability Assessment Rae Zimmerman, New York University
Game-Theoretic Approaches to Critical Infrastructure Protection, Vicki Bier, University of Wisconsin, School of Engineering
Homeland Security Protection in Los Angeles, Mayor James K. Hahn, City of Los Angeles
Distribution of Transnational Terrorism Among Countries After 9/11: Implications for Homeland Security Todd Sandler, USC International Relations
The Economic Impact of Terrorist Attacks, James Moore, USC Viterbi School of Engineering
Planning Models for Emergency Response, Richard Larson, MIT School of Engineering
Reducing the Threat of Terrorism Through Research, Moderator: Erroll Southers, Office of the Governor of California, Deputy Director, Office of Homeland Security
Jack Riley, Director, RAND Homeland Security Center
Bill Colston, Director, Lawrence Livermore National Laboratory Biodefense Knowledge Center
Chris Bellavita, Director, Naval Postgraduate School Homeland Security Center
Randolph Hall, co-Director of CREATE, University of Southern California
Table E-3. Terrorism Risk Analysis A CREATE Research Symposium, January, 2005

Welcome
Randolph Hall, Co-Director of CREATE, USC Viterbi School of Engineering

Overview of the Symposium
Vicki Bier, University of Wisconsin-Madison & Center for Human Performance and Risk Analysis
Detlof von Winterfeldt, Co-Director of CREATE, USC School of Policy, Planning & Development

Deploying Counter-Terrorism Resources Cost-Effectively
William Rowe, Rowe Research & Engineering Associates, Inc.

Security Management System: Automated Solution to Terrorism Risk Analysis
Frank Moret, General Dynamics & Jack Brinson, Oracle Corporation

A Framework for Risk Modeling of Infrastructure Interdependencies
Yacov Haimes & Joost Santos, University of Virginia

Risk Analysis for Interdependent Security Problems
Howard Kunreuther & Erwann Michel-Kerjan, University of Pennsylvania

Risk Analysis for Critical Infrastructure and Key Assets Protection: Methods and Challenges
Bilal Ayyub, University of Maryland

Assessing Infrastructure Critical Locations
George Apostolakis, Massachusetts Institute of Technology

Quantifying Vulnerability to Critical Infrastructure Systems
Barry Ezell, The Army School System Directorate

Outside of the Box: Indicator Based Assessments for Terrorist Attacks Against Critical Infrastructure
Rae Zimmerman, New York University

A Robust Decision Approach to Countering Terrorism
Steven Popper & Robert Lempert, The RAND Corporation

Using Project Risk Analysis to Counter Terrorism
Detlof von Winterfeldt & Heather Rosoff, University of Southern California

Use of Terrorism Catastrophe Risk Modeling to Manage Terrorism Exposure in the Insurance Industry
Jack Seaquist, AIR Worldwide, Inc.

An Overarching Model for the Assessment of Terrorist Threats
Elisabeth Paté-Cornell, Stanford University

Critical Facility Terrorist Risk Assessment and Estimates of Nationwide Terrorism Risk
James Johnson, Mohammed Khater & Dennis Kusak, EQUECAT, Inc.

Robust Terrorism Risk Assessment to Inform Resource Allocation Decision Making
Henry Willis, Andrew Morral, Terrence Kelly & James Medby, The RAND Corporation

Optimal Defense Strategies in the Face of Different Valuations Between Attacker and Defenders
Vicki Bier, Santiago Oliveros & Larry Samuelson, University of Wisconsin-Madison
Table E-4. Agenda for Maritime Cargo Security Conference

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>8:30-9:30 a.m.</td>
<td>Registration and morning refreshments</td>
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<tr>
<td>9:30 a.m.</td>
<td>Introduction: James A. Fawcett, Director, Marine Science &amp; Policy Outreach, USC Sea Grant; Conference Chair</td>
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<tr>
<td>9:45 a.m.</td>
<td><strong>Keynote Address:</strong> The Honorable Don Knabe, Los Angeles County Supervisor (4th District)</td>
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<td>Introduction: Linda Duguay, Director, USC Sea Grant Program; Associate Director, Wrigley Institute for Environmental Studies</td>
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<tr>
<td>10:15-11:45 a.m.</td>
<td><strong>What are the Risks from Maritime Cargo Movement?</strong></td>
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<td></td>
<td>Moderator: Randolph Hall, Professor of Industrial and Systems Engineering; Senior Associate Dean of Research, USC Viterbi School of Engineering; Co-Director, USC CREATE</td>
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<tr>
<td></td>
<td>Dottt von Winterfeldt, Professor of Public Policy and Management; Deputy Dean, USC School of Policy, Planning and Development; Co-Director, USC CREATE</td>
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<td></td>
<td>Noel Cunningham, Director of Operations and Emergency Management, Port of Los Angeles</td>
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<td></td>
<td>Domenick L. Mineo, Professor of Earth Sciences, East Los Angeles College, representing the International Longshore and Warehouse Union</td>
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<td>LCDR Drew Cromwell, U.S. Coast Guard, Assistant Chief, Planning Department, Marine Safety Office/Group, Los Angeles-Long Beach</td>
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<tr>
<td>12 noon</td>
<td>Luncheon (Davidson Conference Center)</td>
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<tr>
<td>2:45 p.m.</td>
<td><strong>Luncheon Speaker:</strong> The Honorable Dana Rohrabacher (Congress, 46th District)</td>
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<td>Introduction: Anthony Michaels, Director, USC Wrigley Institute for Environmental Studies</td>
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<tr>
<td>3:00-4:45 p.m.</td>
<td><strong>What Are the Economic and Political Costs of Prevention and Response?</strong></td>
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<td>Moderator: Steven L. Levy, Professor of International Relations; Director, USC School of International Relations</td>
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<td></td>
<td>Peter Gordon, Professor of Planning and Economics, USC School of Policy, Planning and Development</td>
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<td></td>
<td>Wally Baker, Senior Vice President, Economic and Public Policy Consulting, Los Angeles County Economic Development Corporation</td>
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<tr>
<td></td>
<td>Steven P. Erie, Professor of Political Science; Director, Urban Studies and Planning Program, University of California, San Diego</td>
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<tr>
<td>2:45-3:00 p.m.</td>
<td>Break</td>
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<tr>
<td>3:00-4:30 p.m.</td>
<td><strong>Action:</strong> Planning, Education and Prevention</td>
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<tr>
<td></td>
<td>Moderator: James A. Fawcett, USC Sea Grant Program</td>
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<tr>
<td></td>
<td>CAPT Peter V. Nafzinger, U.S. Coast Guard, Commanding Officer, Marine Safety Office/Group, Los Angeles-Long Beach</td>
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<td>Lt. Angelino Gonzalez, Los Angeles Sheriff's Department Emergency Operations Bureau</td>
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<td></td>
<td>Genevieve Giuliano, Professor of Planning, USC School of Policy, Planning and Development; Director, METRANS</td>
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<tr>
<td></td>
<td>Martin H. Krieger, Professor of Planning, USC School of Policy, Planning and Development</td>
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<tr>
<td>3:30-5:30 p.m.</td>
<td><strong>Reception:</strong> Davidson Conference Center Vineyard Room</td>
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Table E-5. National Symposium on the Future of Terrorism Risk Insurance

Private insurers, and their reinsurers, may ultimately pay well in excess of $20 billion in claims resulting from the terrorist attacks of September 11, 2001, making the attack by far the largest single catastrophic loss the global insurance industry has suffered in history. In the month after September 11, there was widespread belief that another comparable attack in the short term threatened the financial solvency of the insurance industry and its ability to protect public and private property. In response, the federal government passed the 2002 Terrorism Risk Insurance Act (TRIA). The TRIA created a three-year federal program to support the "research and analysis of the market for private insurance against losses from terrorist attacks in order to protect the public." The program is scheduled to expire this year. A long-term solution to tailoring such risk is critically important and this symposium will address these and other important long-term issues.

Table E-6. CREATE Symposium -- Economic Costs and Consequences of Terrorist Attacks 2005

CREATE SYMPOSIUM
Friday, August 19, 2005

CONTINENTAL BREAKFAST, ROOM 103
Welcome
CREATE Director Detlof von Winterfeldt, University of Southern California

Introductions
James E. Moore, II, University of Southern California

Terrorism: Considering New Policies
Bruno S. Frey and Simon Luechinger, University of Zurich

The Economic Cost of Ill-Intentions: Permanent or Ephemeral?
Matthew Drennan, University of California at Los Angeles

Coffee Break

A Worst Case Electricity Scenario: The Benefits & Costs of Prevention
Robert E. Schuler, Cornell University

Tourism and Terrorism: The National and International Economic Impacts of Attacks on Major U.S. Theme Parks
Harry W. Richardson, Peter Gordon, James E. Moore, II, Soojung Kim and Jiyoung Park, University of Southern California, and Qisheng Pan, Texas Southern University

Coffee Break

Development of Risk Metrics for Catastrophic Events in Food Supply
Hamid Mohtadi, University of Minnesota and University of Wisconsin and Antu Panini Murishid, University of Wisconsin

Risk and Economic Costs of a Terrorist Attack on the Electric System
Rae Zimmerman, Carlos Rausin, J.S. Simonoff, New York University and Lester Lave, Carnegie-Mellon University

Lunch

Regional Economic Impacts of Terrorist Attacks on the Electric Power System of Los Angeles: A Computable General Equilibrium Analysis
Adam Rose and Ghaitho Okdwan, Pennsylvania State University

Balancing Freedom and Security After 9/11: The Challenge Faced by the National Park Service
Larry Parkinson and Linda Scarlett, U.S. Department of the Interior

Coffee Break

Estimating the National Economic Cost of Food Terrorism
Tom Simon, University of Minnesota

Publication Plans and Drafting Requirements
Harry W. Richardson, University of Southern California

Concluding Comments and Adjournment
Peter Gordon, University of Southern California

CREATE SYMPOSIUM
Saturday, August 20, 2005

CONTINENTAL BREAKFAST, ROOM 103

Two-Sided Electricity Markets: Self-Healing Systems
Richard E. Schuler, Cornell University

Tourism and Terrorism: The National and International Economic Impacts of Attack On Major U.S. Theme Parks
Harry W. Richardson, Peter Gordon, James E. Moore, II, Soojung Kim and Jiyoung Park, University of Southern California, and Qisheng Pan, Texas Southern University

Coffee Break

Development of Risk Metrics for Catastrophic Events in Food Supply
Hamid Mohtadi, University of Minnesota and University of Wisconsin and Antu Panini Murishid, University of Wisconsin

Risk and Economic Costs of a Terrorist Attack on the Electric System
Rae Zimmerman, Carlos Rausin, J.S. Simonoff, New York University and Lester Lave, Carnegie-Mellon University

Lunch

Regional Economic Impacts of Terrorist Attacks on the Electric Power System of Los Angeles: A Computable General Equilibrium Analysis
Adam Rose and Ghaitho Okdwan, Pennsylvania State University

Balancing Freedom and Security After 9/11: The Challenge Faced by the National Park Service
Larry Parkinson and Linda Scarlett, U.S. Department of the Interior

Coffee Break

Estimating the National Economic Cost of Food Terrorism
Tom Simon, University of Minnesota

Publication Plans and Drafting Requirements
Harry W. Richardson, University of Southern California

Concluding Comments and Adjournment
Peter Gordon, University of Southern California
Table E-7. US/UK Building Partnerships for Homeland Security Solutions

"Building US/UK Partnerships for Homeland Security Solutions"
Davidson Conference Center
University of Southern California
Thursday, September 8, 2005

7:45 – 8:30 Registration/Continental Breakfast
8:30 – 8:35 Opening and Welcome remarks – Provost C.L. Max Nikias, USC
8:35 – 8:40 Welcome remarks, Brian Conley, Deputy Consul-General, British Consulate-General, Los Angeles
8:40 – 8:45 Los Angeles County Sheriff Lee Baca
8:45 – 9:10 Bob Peirce, Consul-General, British Consulate-General, Los Angeles
9:10 – 10:40 Panel – Risk and Economic Assessment of Terrorist Threats
Moderated by Detlof von Winterfeldt, Director, CREATE
• John Stammreich, Vice President, Homeland Security/Phantom Works, The Boeing Company
• John Simpson, Director, UK Health Protection Agency Centre for Emergency Preparedness and Response, Porton Down
• Neil Blais, Director, ABS Consulting
• Douglas Johnson-Poensgen, Executive Director, SERCO Consulting
• Randolph Hall, Vice Provost for Research Advancement, University of Southern California & Mike Orosz, Computer Scientist & CREATE Risk Analysis Workbench Project Lead, Information Sciences Institute
10:40 – 11:00 Coffee Break
11:00 – 12:15 Panel – Biometrics for Personal Identification
Moderated by Martin George, CEO, Smart Sensors Limited
• Gerald Buckwalter, Head of Homeland Security, Northrop Grumman Corporation
• David McIntosh, Chief Executive Officer, OmniPerception Ltd
• Douglas Buettner, Engineering Specialist, The Aerospace Corporation
• Mike Fairhurst, Head of Department of Electronics, University Of Kent
12:15 – 1:30 Lunch with remarks by Matt Bettenhausen, Director of the California Office of Homeland Security
1:30 – 3:00 Panel – Sensing Systems and Sensor Networks
Moderated by Mike Anderson, VP of Sales & Marketing, Radiation Watch Ltd
• Don Frosnitz, Deputy Director of Homeland Security, Lawrence Livermore National Laboratory
• D.K. Arvind, Director of the Speckled Computing Project, University Of Edinburgh
• Dennis Richman, Raytheon Airborne Integrated Mission Systems (AIMS) & Raytheon Space & Airborne Systems (SAS)
• Ruth Woodward, Science and Technology Adviser, HT Consultants Ltd
• Ron Stoltz, Homeland Security, Sandia Laboratories
3:00 – 3:20 Coffee Break
3:20 – 4:50 Panel – Information Management, Information Security and Data Mining
Moderated by Terry Benzel, Deputy Director Computer Networks Division, Information Sciences Institute
• Tom Dillon, Senior Vice President & Deputy General Manager, Commercial Services Business Unit, Science Applications International Corporation
• John Anderson, Technical Leader for Homeland Security, BAE Systems Advanced Technology Centre
• Lisa Sokol, Technical Director, General Dynamics
• Steve Kingan, Chief Executive Officer, Nexor
• Carl Blanchard, Homeland Security Systems, Lockheed Martin
4:50 – 5:00 Concluding Remarks – Bob Peirce & Randolph Hall
5:00 – 6:00 Networking Reception in the Vineyard Room – All Attendees Welcome
Table E-8. Regional Intelligence Conference

Regional Intelligence Conference
Embassy Room
2-3 February 2006
University of Southern California

Thursday 2 February 2006

1:30 pm  Introduction

2:00 pm  Plenary Session: Mark Lowenthal, President & CEO of the Intelligence & Security Academy, LLC.

3:00 pm  Break

3:15 pm  Panel One “Intelligence Community Today”
  1. Paul Johnson, Director, CSI
  2. Dr. William Nolte is Deputy Assistant Director of Central Intelligence for Analysis and Production
  3. John Kring, Director of Intelligence, CIA and former Director of the DCI's Crime & Narcotics Center

5pm  Reception
Main Lobby

6pm Dinner  Speaker: Jennifer Sims, core faculty, Georgetown's School of Foreign Service as Visiting Professor, Security Studies Program. Co-editor with Burton Gerber of Transforming US Intelligence, a volume released in September 2005.
Vineyard Room

Friday 3 February 2006

8:45 am  Panel Two: "Homeland Security, Intelligence and Risk Analysis" (Host: USC Center for Risk & Economic Analysis of Terrorism Events)
  1. Detlof von Winterfeldt (commentator), Director of CREATE
  2. Dr. Henry H. Willis, Policy Researcher, the RAND Corporation, Pittsburgh
  3. Todd Sandler, Robert & Kay Dockson Chair in International Relations and Economics, USC
4. Dr. Steve P. Bennett, US Homeland Security, National Biodefense Analysis & Countermeasures Center

10:15 am  Break

10:30 am  Panel Three: “What to Expect from Intelligence”  An epistemological discussion of intelligence: what it is possible to know; what intelligence can be expected to predict, what it cannot
Panelists:
1. Martin C. Peterson, Business Development Manager, Science Applications International Corporation
2. John C. Gannon, Vice President for Global Analysis, BAE Systems
3. Dr. Woodrow J. Kuhns, CSI

12:00 Lunch Board Room  Greg Treverton, Senior Policy Analyst, RAND Corporation & Associate Dean of the RAND Graduate School

1:30 pm  Panel Four: “Public Diplomacy and Intelligence” (Host Center on Public Diplomacy, USC Annenberg School for Communications)
1. Nicolas Cull, Director & Professor, USC Program on Public Diplomacy
2. Giles Scott-Smith, Senior Researcher at the Roosevelt Centre in The Netherlands
3. Kevin O’Connell, Senior International Policy Analyst and Manager, Intelligence Community Programs at the RAND Corporation

3:00 pm  Break

3:15 pm  Panel Five: “Intelligence and the Academy: Relations between Intelligence Community and US Institutions of Higher Education, Past, Present, and Future”
Panelists:
1. Donald Steury (commentator), CIA Senior Historian
2. Michael Turner, Cannon Professor of International Relations and Peace Studies, Alliant International University
3. Steven Lamy, USC, School of International Relations Director & Professor
Table E-9. The Risks and Economic Impacts of Terrorist Attacks

“The Risk and Economic Impacts of Terrorist Attacks”
Town & Gown
University of Southern California
May 17, 2006

DRAFT Agenda

8:30 a.m. Breakfast

9:00 – 9:15 Welcome by Distinguished Guest (Invited)

9:15 – 9:30 CREATE Overview
Detlof von Winterfeldt - Director of CREATE and Professor of Public Policy and Management, University of Southern California

9:30 – 10:30 Keynote
Rear Admiral William D. Sullivan - Vice Director for Strategic Plans and Policy, The Pentagon

10:30 – 11:00 Break

11:00 – 12:30 Risk Based Decision Making Panel
Don Kleinmuntz - Professor of Business Administration, University of Illinois at Urbana-Champaign
Randy Hall – Vice Provost for Research Advancement, University of Southern California
Alexia Brunet – Assistant Professor, Northwestern University School of Law

12:30 – 1:30 Lunch & Keynote: TBD

1:30 – 3:00 Economic Impacts of Terrorism Panel
Adam Rose – Professor of Economics, Pennsylvania State University
Michael Intriligator – Professor of Economics, Political Science, and Public Policy, University of California, Los Angeles
Jim Moore II – Professor of Industrial and Systems Engineering, University of Southern California

3:00 – 3:15 Break

3:15 – 4:45 Bio-Terrorism Panel
Steve Bennett - Bioterrorism Risk Assessment Program Manager, Biological Threat Characterization Program, National Biodefense Analysis and Countermeasures Center, U.S. Department of Homeland Security
Elin Gursky – Principal Deputy for Biodefense, National Strategies Support Directorate, ANSER
Lorna Zach – Scientist, University of Wisconsin, Madison
Terry O'Sullivan – Post-doctoral Research Associate, CREATE