1. Executive Summary

Objectives. The central objectives of this study are to describe and model the dynamic complexity that
underlies a community’s response to a terrorist strike and to estimate how behavioral responses affect
economic impacts. Emergency response systems, information and communication channels, and social
support organizations are likely to interact with the particular characteristics of a terrorist event in a
nonlinear fashion to produce a wide range of physical, social, and economic impacts. Building on the
theoretical framework of the social amplification of risk, and guided by systems thinking, this study
addresses the following questions: 1) What are the requisite factors to adequately forecast the impacts of a
disaster and most particularly a terrorist strike? 2) How can risk perception be incorporated into an
economic model that predicts regional or national impacts? 3) How does resilience (the ability of a
community to maintain function when shocked) affect predicted responses to catastrophic events? 4)
How do these factors change and interact over time reflecting the dynamic nature of community
response? 5) What are the important structural mechanisms that drive such change, especially system
feedbacks and delays? 6) How do different responses to risk across gender, age, ethnicity, and income
affect these mechanisms? 7) What perspectives and assumptions does a community bring to such a crisis
that helps or hinders its ability to prepare, respond and recover? 8) What policies can be implemented that
may mitigate the long-term impacts of such an event?

System Dynamics Modeling. Over this year a system dynamics model was developed that looks at
community response to different types of disasters (Pavlov & Burns, 2009). This model expands on
systems modeling depicted by Burns and Slovic (2007). This current model incorporates event risk signal
and media coverage as before, but now includes perceived trust and perceived managerial competence as
a means of simulating the diffusion of fear following different types of disasters (especially terrorism).
This new model also includes a subjective assessment of economic activity as an output variable. It turned
out that risk signal, trust and perceived managerial competence were very important in determining levels
of fear and economic impacts.

CGE Modeling. Efforts over the last year have focused on developing an approach that allows a rigorous
estimation of the additional economic costs attributable to fear following a disaster. Three hypothetical
scenarios have been developed that occur in financial district of Los Angeles: 6.0 earthquake, terrorist
chlorine release and dirty bomb. In the previous year the requisite economic equations for a CGE model
of Los Angeles County were constructed. This year we have focused on obtaining economic data and interviewing experts to determine the direct costs of each scenario and to designing a survey experiment that would provide insights into the indirect costs of such an event. We found that in terms of the directs costs associated with a disaster business interruption was the most influential.

**Risk Perception and Risk Communication Workshop.** A workshop was conducted this summer that brought together researchers from many disciplines and DHS university centers to discuss advances in risk perception and related policy research as well as the modeling of public response amidst disasters.

2. **Research Accomplishments**

2.1. **System Dynamic Modeling of Public Response**

From the system dynamics perspective, we formulated a dynamic hypothesis of how such impacts might work in the form of a causal loop diagram as depicted in Figure below (Pavlov & Burns, 2009). It turns out that these dynamics can be represented as the interaction of two opposing feedback loops. The first involves media and public response, which tends to amplify the risks and potential consequences from an event (reinforcing loop). The second involves response by the larger community, which tends to attenuate the risks by initializing emergency response protocols and offering support and reassurance (balancing loop). We then created a stock and flow model to simulate the diffusion of media coverage, fear and economic impact. These simulations represent exploratory efforts only. However, these preliminary findings suggest that following a high signal event (e.g. terrorist attack, biological or radiological accident) fear in a community will rise quickly but come down slowly. Largely caused by fear, economic impacts will continue to increase for sometime after the event. Likewise, trust in local authorities prior to the event may greatly mitigate these outcomes.
2.2. GCE Modeling

We measured direct costs by calculating the fatalities and injuries, property damage and business interruption for each scenario. Sensitivity analysis revealed that business interruption clearly has the largest impact on direct costs. For fatalities and property damage we are using model simulations provided by a Long Beach based firm ImageCat, a chlorine diffusion model developed by one of our team who is a chemical engineer, models developed by PACER one of the DHS university centers and the DHS National Planning Scenarios. We also did extensive on-the-ground reconnaissance to determine how many people would be exposed to harm during a chlorine and dirty bomb release. For business interruption we are used the modeling approaches just mentioned but we also worked with the general manager of the Emergency Management Department for the City of Los Angeles and his team. In addition, we met with the CEO of the Los Angeles Emergency Preparedness Foundation.

Estimating Secondary Costs. We plan to measure secondary costs in three ways. The first is by examining consumer reduction in spending of products and services originating in Los Angeles due the region being stigmatized because of a particular disaster. The second is by looking at demand for increased wages due to heightened perceived risk following a disaster, especially terrorism. Regarding these first two, pilot studies that look at different types of disasters will be in November. The third is by investigating how business investors in Los Angeles increase their required rate of return due to a heightened sense of business risk.

A National Survey. To estimate these indirect costs due to public response (i.e. reduced consumption and demand for increased wages) we are designing an on-line experiment involving a nationally diverse panel with a concentration of respondents living in Los Angeles. The focus of this present survey will be in estimating consumption and wage decisions of respondents exposed to our three disaster scenarios. The scenarios themselves will vary by level of fatalities and extent of long-term damages to the region.

Following a terrorist strike investors are likely to be wary of investing funds in businesses associated with the affected area. To assess business investors’ propensity to increase their required rate of return before committing their capital in ventures in the Los Angeles area we plan to conduct interviews with Los Angeles business people in December 2009. These interviews are to be arranged by the CEO of the Los Angeles Emergency Preparedness Foundation mentioned previously.

We formulated a CGE model of Los Angeles and have estimated the direct impacts of an earthquake, chlorine release and dirty bomb. A CGE simulation was run to investigate how large an impact heightened perceived risk and fear might have on the GRP of Los Angeles following a high signal event. James Giesecke and Adam Rose ran a trial simulation of the Los Angeles County Computable General Equilibrium (CGE) model for the dirty bomb scenario. Scenario parameters were derived in conjunction with project team members Bill Burns, Tony Barrett, Ergin Bayrack, and summer intern, Michael Suher (Ph. D. student in economics at Brown University). We used sectoral employment data for the LA central business district to estimate direct impacts on gross county product (GCP) of about $2.1 billion over a period of a few weeks during which a portion of downtown Los Angeles would be quarantined and cleaned up. We then summarized the following three stylized reactions associated with the social amplification of risk:

1. Increased investor required rates of return in the CBD by 3 percent above current levels (note this is 3 percent of base levels and not 3 percentage points).
2. Increased labor's required remuneration to work in the CBD by 3 percent
3. Decreased willingness to pay for CBD-origin commodities by 3 percent
The results indicate the following impacts for a typical year in the long run:

1. Rate of return premium: $993 million
2. Wage premium: $950 million
3. Willingness to pay premium: $1,179

The total $3.1 billion impact is 150 percent of the direct impacts. Moreover, these behavioral linkage impacts would likely be effective for 3-5 years, thus increasing this ratio several fold.

We are currently in a process of estimating the various premia more precisely, as well as measuring potential resilience offsets to direct damage from factors such as business relocation.

### 2.3. Risk Perception and Risk Communication Workshop

Working with colleagues at CREATE and Pacific Northwest National Labs (PNNL) Paul Slovic and Bill Burns hosted a risk perception and risk communication workshop in Eugene Oregon (home of Decision Research) in August 2009. Please see the link to the workshop and its presentations and simulations below. We invited a diverse group of researchers to spend two days discussing their work and participating in two interesting threat scenarios. The scenarios involved a flu outbreak and dirty bomb release both occurring in the Los Angeles area. During the scenario simulations participants placed themselves in the role of different community members (e.g. health care worker) and different community leader roles (e.g. mayor). We were especially eager to learn of work that would suggest key factors that drive risk perception and fear as well as risk communication strategies that might mitigate such fear. By many accounts this workshop was quite successful and has facilitated an intent to form future collaborative relationships.

### 3. Applied Relevance

These findings should be of interest to researchers and practitioners because perceptions of risk, trust, and level of preparedness are some of the many important determinants of public response to current threats. Such factors may influence our willingness to use public transportation, become vaccinated, attend public events, eat certain foods, spend money or comply with warnings to evacuate or shelter in place. These choices may, under certain circumstances, have significant consequences for communities and even nations. Risk perceptions, trust and risk-related behaviors may also influence policy at both the local and national levels. Consider the response (largely risk communications) to the H1N1 outbreak at both the national (CDC) and local (school systems) levels. System dynamics modeling may not only provide insight into the diffusion of fear amidst a disaster but allow the simulation of policy in advance of a crisis.

The CGE modeling currently seeks to estimate the impacts of different types of disasters with the idea of examining how fear and other emotions translate into economic consequences. Understanding these indirect costs may aid the design of risk communications used to mitigate these outcomes.

### 4. Collaborative Projects

As mentioned above, this previous August a risk perception and risk communication workshop was held in Eugene OR that brought together leading scholars including ten researchers from the DHS university
centers (CREATE, START, NCFPD) and three from the Pacific Northwest National Lab. A representative from the DHS university programs also attended. The primary purpose of the workshop was to encourage collaboration among scientists across university centers. Two simulation exercises were done during the workshop that represented ongoing research by several teams of CREATE investigators. Please see the following link for workshop content http://www.decisionresearch.org/people/burns/threat.html. A follow up conference is planned for February 2010 at CREATE. From this conference we will invite papers to be part of a special issue of Risk Analysis.

5. **Research Products**

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<td>5b # of scholarly presentations (conferences, workshops, seminars)</td>
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5.1. **Publications and Reports**

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<tr>
<td>Burns, William; Slovic, Paul - Decision Research</td>
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5.2. Presentations - Conferences

2. Burns, W., “Public Response to Crisis: Perceptions of Risk, Recovery and Economic Impacts”, College of Business, University of Iowa, Iowa City, Iowa, November 12, 2009

5.3. Presentations - Outreach


6. Education and Outreach Products

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- Met with Matt Clark at DHS in March 2009
- Brown bag presentation at DHS June 2009
- Met with Marylyn Morgan August 2009 at workshop in Eugene OR.