1 Exploratory Research

1.1 Preliminary work on untested and novel ideas

Security index is a new concept based on the Bayesian approach ref. [3,12]. The validity of the methodology can be examined by comparing the pre- and post-event data collected by the team.

1.2 Emerging and transformative research ideas: new expertise and new approaches

Previous computations of system reliability have been confined to mean-(average) driven statistical analysis, ref. [1]. For extreme events like severe hurricanes such assumptions are not suitable. The concept of extreme value statistics, ref. [2,4] must be implemented to design future relief measures.

Combination of network theory and extreme value statistics will introduce a new concept within the context of Bayesian networks, ref. [7].

1.3 Enhancing "established" research topics

Engineering safety analysis is widely employed in a variety of problems. A number of computer programs are currently available for such probabilistic approaches. Here, to be able to provide better disaster relief, the methodology of safety engineering is enhanced to address issues related to security engineering (`http://www.columbia.edu/~gd18/LiveDesign`).

1.4 A severe urgency

In the aftermath of Katrina, analysis of public's hurricane related experiences with civic services is both opportune and extremely urgent. The big picture calls for the rethinking of roles of relief, rescue and evacuation organizations in the aftermath of a natural or manmade disaster.

1.5 Quick-response to available data

The team will start collecting data as soon as it is possible to contact the citizens and authorities in the Katrina hit areas. Exact location and timing will be decided after the first meeting of the principal investigators within a week of the award.

1.6 Unanticipated natural disasters

Earthquakes, landslides, flooding and forest fires pose some common challenges for the civic authorities. The general concept of security index is anticipated to be useful in all natural disasters.

Human ill-preparedness caused some of the worst discrepancies between preplanned actions and actual events, as evidenced in a number of nursing homes. The team will focus on analysis that will identify specific bottle-necks to make effective interaction between organizations (government and private) involved in emergency preparedness.

1.7 Efforts to catalyze rapid and innovative advances

There is no more pressing problem than implementing Katrina experiences to secure citizens in future disasters. The solution involves HSD and ENG divisions of the NSF. It is anticipated that multi-year multi-disciplinary research, which will address security concerns based on our past experiences (such as 9/11 and Katrina), will be announced in the near future by various levels of the federal, state and local governments. The team brings an important basic mathematical tool to analyze human experiences in the aftermath of a disaster in this SGER proposal.

2 Research basis from data collection: Human aspects

2.1 Civic authorities

Disasters disturb the social system and the different organizations that compose this system. The first responders are composed of fire departments, volunteer organizations and police forces. These organizations have a recognized responsibility to respond to disasters. Also, when disasters such as hurricane Katrina strike, organizations must coordinate their actions in order to respond with effectiveness.

2.1.1 Coordination

To survive, organizations must interact with their environment. They must develop links with other organizations in their environment in order to exchange resources. In their usual activities, actors have time to interact, exchange and negotiate these resources; they work in their usual activities, frameworks, and make decisions for future projects (Gillespie and Mileti, 1979). When organizations are faced with a turbulent environment (like a disaster or crisis), normal exchange links are disturbed. Some organizations are able to maintain their normal links, and others must develop new strategies to obtain the necessary resources for their survival and accomplish their new activities (Denis, 1990). New links can be created and old ones can fail. In times of disaster, usual links can become more numerous and more complex, if organizations work to respond to the increase in demand that they receive (Streeter, 1989).

2.2 A Network model

It is advantageous to conceive the organizational environment as a network of exchange as organizations must interact to obtain needed resources. An interorganizational network is therefore a group of organizations in the environment, grouped around stable and repeated exchanges. To understand complex decision making processes, the notion of network can be seen as a function which integrates resources (Hellgren and Stjernberg, 1987).

2.2.1 Nondeterministic model

If resources are scarce and concentrated, the organizational environment is source of uncertainty. The level of uncertainty is linked to the dependence and power relations between organizations. Also, uncertainty may come from a lack of information to the decision makers, or because this information is not trustworthy (Streeter, 1989). Uncertainty is also linked to the perception of the decision maker; what is uncertainty to one decision maker is not necessarily uncertainty to another. Faced with turbulence, the decision maker will determine the scope of uncertainty (Denis, 1990). Uncertainty is therefore subjective, based on the diagnosis and evaluation of the decision maker, and on the response capacity of the organization.

When interorganizational networks are identified, it is possible to use the hyperspace of danger to analyze the strategies of the stakeholders. The hyperspace of danger is composed of five axes which is the base of "danger and its relationship with survival" (Kervern, 1995). The mnemic axis consists primarily in the organizational memory, the data banks, the cases, etc. The epistemic axis is the knowledge bank and the modeling of the components of the system. The teleological axis represents the finalities of the system which must animate all the stakeholders. The axiologic axis represents the values of the system. Finally, the deontologic axis is composed of the rules which the stakeholders chose. Each organization embedded in a network (for example local and state emergency management agencies and FEMA) has its own space of danger; the distances between the axes of their respective spaces represent the dissonances which exist between their perception of the danger in the system. The dissonances, like uncertainties associated with each axis, are aggravating factors of danger.

The principal theoretical guides which will be used for this research will be: work developed by Kervern (1995) on danger sciences (cindynics) and also socio-technological risk (Denis, 1998; Lagadec, 1981; Pauchant and Mitroff, 1995), concepts of interorganizational networks (Cook, 1977; Perrow, 1986;

Hellgren and Stjernberg, 1987;) and concept of interorganizational networks in the context of socio-technological risk management (Therrien, 1995), and in systemic analysis (Pauchant and Mitroff, 1995; Mitroff and Pauchant, 1990).

2.3 The basis for defining security indices

In the model developed by Therrien (1998, 2003), an instant is represented by events, which involve decisions, which themselves have effects. The instant represents the model that each agency has. The instant is not the same for each agency; however, the experiences and the decisions it describes have effects, which can affect the instants of the other agencies involved in the same event(s). For example, during the response to Hurricane Katrina, many comments were made on the discrepancies between the decision-making of FEMA and the City of New Orleans. They were important protagonists in the management of the event, sharing many instants, but had many different effects because of a lack of coordination. To represent complexity related to instant, it is possible to make a projection on the principal dimensions of complexity, therefore to represent it in a hyperspace. The hyperspace of the complexity of an instant is composed of:

1. uncertainty on the data: a agency does not know necessarily all the data;
2. uncertainty on the models: a agency does not always have the models of behavior for the event, other agency of the system, etc;
3. tangle of the networks: a agency is part of a system in which several decisions can influence its own decisions;
4. uncertainty related to the solutions considered: a agency does not always know the effects its decisions will have;
5. limitation of the means: there is a limited number of means which the agencies can use to manage their resources.

2.4 Qualitative depiction

The hyperspace of complexity helps us draw a model which can calculate the differences on the five axes described above in a qualitative manner. The results of these differences can help to indicate strategic bridges between the organizations without causing major disruptions in the actual organizations. Conserving complexity helps in determining strategies of change which respect the actual structures and cultures of the organizations.

On another level, the hyperspace of complexity can also be used as a tool to calculate a potential level of danger. An instant is in a hyperspace of complexity in a similar manner to the hyperspace of danger suggested by the cindynics (danger sciences). As Wybo (1998) proposes, one can at every moment allot an evaluation of the level of danger and his evolution with the succession of the instants according the five axes of cindynics. To each situation corresponds a space of danger with its five components, which allows estimating, with the means of a metric specific to the type of danger, a total level of danger. Between two situations, we define a cycle of evolution formed of four phases: perception, analysis, decision and latency (Wybo, 1998)

Each instant contains the behavior of each agency (Nicolet, 1998) in:

(a) the acquired experience;

(b) the models used;

(c) the finalities which guide it;

(d) the knowledge of the rules to be followed;

(e) and the values it upholds.

Therefore, by calculating qualitatively the differences that exist between the instants of each agency, we can determine a potential level of danger. For example, we could determine that the differences between the five axes of the instant are so large between FEMA and the City of New Orleans, that this represents a potential for difficulties in coordination. The complex system of the response network to Katrina can be represented by a general context and contexts associated with each organization, understanding a system of instants.

The first objective of this model will be to preserve information that was experienced by each organization in order to return accessible information while respecting the context of the decisions.

The second objective of this model will consist of developing a metric of measuring potential danger. This measure will be obtained by calculating the differences between the different instants of each agency.

3 Organizational roles on human experiences

This part of the research will start after the collection of data by the team.

3.1 The main question

The intriguing question:
"*How theory and practice differ in actuality?*"

Dasgupta studied this problem with his research partners from Japan in modeling fire escapes using *cellular automata* and *combinatorics on words* [8]. The *basic rules* were extracted from a number of mock evacuations. This uncertainty must be realized to design emergency relief efforts based on human experiences. In actuality people followed different courses under conditions of panic. Our foreign collaborators have specifically studied emergency models of water conduits and roles of environmental assessments [5, 11].

In particular, the question relating to differences between plans and events will be the starting point for investigating the organizational nature of the agencies involved in the response to the devastation wrought by Hurricane Katrina. On the other hand, there was a "theoretical model" of how the various responding agencies should work together, and on the other hand there was the actual response documented in various forms. Needless to say, the actual response deviated considerably from the theoretically sound idealized model.

3.2 Mathematical model

In various management plans, which focus on human experiences, interactions among groups have been successfully modeled using network theory. Mathematically speaking, networks have been analyzed based on common membership, information flow, acquaintanceship, communication, to name a few.

The team will utilize experiences from previous successful projects where network analysis has been applied to such diverse groupings as committees in the US House of Representatives and linkages between scientists and kinship structures in various societies. In this project, the team intend to employ computer programs for network analysis to the agencies involved in the response to Hurricane Katrina. Due to the scope of this project, existing software will be used and no new computer program will be developed.

3.3 Specific activities

Markowsky and Dasgupta will investigate the theoretical network structure of the responding agencies based on the official understanding of their responsibilities and relationships. Following that, we will look at the actual network that developed as a result of responding to Katrina.

Answers to the following questions will be sought:

Q-1: What was the theoretical structure and to what extent was it adequate to handle to the response to Katrina?

Q-2: How did the practical structure differ from the theoretical structure?

Q-3: What caused the differences?

Q-4: What would have been the best structure for the agencies to have to respond to Katrina and other large scale disasters?

Q-5: What are the institutional and organizational impediments to practically implementing this ideal structure?

The team will investigate the above issues using the methods of hierarchical analysis and network analysis, [9, 10, 13].

3.4 Human experiences: past, present and future

1. 1. Before weather forecasting, modern safety standards, and civil defense, human experiences of disaster were defined by shock and unpreparedness. In more recent times, such as during 9/11, institutions and physical infrastructure have been capable of mitigating suffering. But the shortcomings of the systems in place have repeatedly been demonstrated. From these events we have learned that the most rigorous yet flexible approaches to planning that are possible are necessary.

2. 2. As we begin to assess Hurricane Katrina, it seems that uncertainty and institutional failure had the greatest effect on community experiences and on public perceptions of the disaster. Katrina provides a window of opportunity to mobilize resources for more effective, rather than simply more, disaster preparedness. Early collection of experiential information is a priority given the dislocation of the region and the possibility that citizens and officials will soon be even more dispersed than they are now.

3. 3. Analysis of disaster events through new statistical approaches enables us to better predict the effect of future disasters on citizens and on the institutions that protect them. The nature of calamity is that it cannot often be foreseen. Understanding complexity and working with the tools necessary to model it are therefore necessary to mitigate human suffering in the future. Bayesian statistical estimates will predict future effects of devastating calamities on citizens. The Bayesian network modeling, [6], will be mostly carried out by Dasgupta.

4 Tasks — Activities by Semesters

4.1 Fall 2005

There will be a two-day organization meeting of the principal investigators. All management details for the project will be sorted. The first visit to New Orleans will be made. Experiences of law enforcement agencies from the States of Louisiana, Mississippi and Alabama will be collected. The first progress report will be published.

4.2 Spring 2006

A second visit will be undertaken. Work from three PIs will be reviewed for synthesis.

The undergraduate student of the team will make a visit — the third one of the project.

In a meeting at the NSF the team will present the overall aims of this human experiences research to mitigate future natural and manmade disasters.

4.3 Summer 2006

The team, in a seminar in Columbia university, will seek the expert opinions of researchers from CU Schools of Social Work and Public Health (Medical Center). The emphasis will be on both physical and mental health.