MCEER RESEARCH TASK STATEMENT

Thrust Area: Multi-Hazard

Budget: Yr 9 Assigned
Project Number: 9.4.4

Task Title:
Extreme Events, Damage to Community Infrastructure and Socio-Economic Relationships, and Recovery Processes in Self-Organizing Systems

Investigator
Daniel Alesch* Gary Dargush, James N. Holly, Stephanie Chang

The project team will be headed by Daniel J. Alesch, Ph.D., Emeritus Professor, and owner of the Applied Analysis Group, LLC., a small business. Alesch is responsible for administration and for leading the community systems construct element of the research.

Professor Gary Dargush, Professor of Engineering, University at Buffalo, will participate as the lead analyst for model building. Dargush will serve as a consultant to the Applied Analysis Group during summer months.

Holly holds a Ph.D. in Organizational Communication from the University of Illinois. He also holds an MBA, MS in Ocean Engineering, BS in Ocean Engineering, and BS in Engineering from the United States Air Force Academy. Holly is uniquely qualified to assist with this research by virtue of working with Alesch for more than a decade on post-disaster recovery of business organizations, local governments, and communities.

Chang, a long time participant in MCEER research, is Associate Professor, University of British Columbia. She is an unpaid collaborator in this research, since it is akin to work she is doing. She will participate as a reviewer and colleague.

*indicates task leader

Statement of Project Goals: (Conceptually describe what the work is intended to accomplish, in 100 words or less. Do not provide detailed description here.)
The immediate project goal is to develop a proposal to NSF for support to investigate the relationship between the extent of losses in a community from an extreme event and recovery prospects and processes. Year 9 MCEER support will enable the team to ascertain the feasibility and desirability of using self-organizing systems concepts to model what happens in communities following extreme events, depending on the amount of damage to artifacts and to social and economic relationships within the community and between the community and other places, pre-event system characteristics, and strategic interventions following the event. This work will build on, complement and support research currently being done by Professor Chang. It builds, too, on previous work conducted by Alesch and Holly under the aegis of the Public Entity Risk Institute.

Problem Description and Research Approach of Proposed Work for Year 9: (Detailed description of research to be conducted and methodology to be used.)
This is a request for funds to support exploratory research. We expect the activity to result in an application for support from the National Science Foundation.

We are trying to understand community recovery processes, particularly in terms of the pre-existing state of the community system, the nature and dimensions of losses from the extreme event, and public strategies employed after the event to attempt to bring the system into
a viable and desirable system state.

Alesch and Holly have been studying more than a dozen communities, each of which has suffered one or more extreme events, for about a decade, doing both longitudinal and cross-sectional analysis. They have learned some things that run counter to conventional wisdom.
- Extreme events of the same magnitude can vary considerably in terms of the damage they do to the community system and to the probability of system recovery
- Community recovery is much more than reconstruction and is neither assured nor linear
- The old saw is that disasters simply accelerate trends that were already in place in a community isn’t always the case
- Recovery depends, to a considerable extent, on the choices made by individual, nongovernmental actors in the system, including whether to stay or leave, reinvest or not.
- Economic recovery depends in part on what happens in other places during reconstruction

At the same time, Professor Chang has been working within MCEER’s Thrust 3 to employ dynamic modeling and regional science concepts to better understand and to model recovery processes. Professor Chang’s work and that of Drs. Alesch and Holly have similar objectives, but take different approaches to developing understanding. We believe that the two approaches may be complementary, and perhaps synergistic. Our mutual long term goals are to develop a theory of community recovery from extreme events, but for this proposal, we have more modest objectives. We want to explore the implications of alternative approaches to modeling recovery processes and gain greater understanding of the relationships between the nature and dimensions of losses within a community and the recovery processes and prospects of the community system. We would like to push the envelope in our collective understanding of recovery processes and modeling those processes.

Alesch, Dargush, and Holly have hypothesized that communities can be modeled as self-organizing systems and that community recovery can be modeled as a spatially-distributed self-organizing system that has experienced a significant perturbation. Alesch and Holly have seen several communities that suffered extreme events that have not recovered socially or economically, including Homestead, Florida, and Montezuma, Georgia. They have seen other communities that have changed substantially, including Northridge, CA, and St. Peter, MN. Some communities rebuild and recover quickly; others do not recover. We suspect that recovery is a function, in large part, of the pre-existing system state and of the damage to the built environment and to social and economic linkages within the community and between the community and other places. People and private organizations choose whether to stay in the damaged community and reinvest or to move on. We hypothesize that they respond to internal and external cues and that governmental intervention can affect those cues.

Our research approach in developing a proposal to the National Science Foundation will be to attempt to apply models based on concepts from self-organizing and cellular automata theory to simulating post-event outcomes in one or more communities, including, quite possibly, the economically devastated area of Lower Manhattan for the period following 9/11.

This is an interdisciplinary effort requiring significant interaction between the participants and the exploration of relationships between concepts that, to our knowledge, have never before been linked. During this exploratory research, extensive interaction is planned among the researchers. Dr. Chang is not requesting financial support from this project, but has proposed to work with the other three members of the team to explore interrelationships, possible synergies between her models and the self-organizing systems model, and means for
better understanding what happens in communities following extreme events. The work proposed here does not duplicate her work. Nor is it competitive. We believe it is complementary to and supportive of her work and that of Professor Adam Rose, but that it takes a different approach that provides the opportunity to predict recovery over a greater range of initial damage to the community system.

The proposed approach is for Alesch, Holly and Dargush to develop a collaborative set of constructs based on work previously conducted by Alesch and Holly in a dozen communities from across the country that suffered one or more extreme events, including flood, earthquake, hurricane, and tornado, and including work by others on Lower Manhattan. Alesch and Holly will provide data on pre-event community system state, direct losses from the extreme event, and post-event activities and outcomes in the community. Dargush will attempt to apply self-organizing systems models to the phenomena. Alesch, Holly, Dargush, and Chang will exchange draft and published papers and will meet at least once for a two-day session to explore their respective approaches, identify critical issues in understanding post-extreme event phenomena in communities, and to push toward greater understanding of recovery processes.

**Assessment of State-of-the-Art:**  *(Describe other relevant work being conducted within and outside of MCEER, and how this project is different.)*

Within MCEER, Chang has been applying regional science methods and economic modeling to assist in understanding recovery processes. Rose has been studying economic resiliency in several contexts. Their work provides a valuable set of perspectives on recovery. No one outside MCEER, to the best of our knowledge, has been attempting to understand post-event processes in communities from the standpoint of the damage to both the built environment and socio-economic linkages within and outside the community system. Nor is anyone attempting to develop theory to explain why some communities recover and others do not. Chang’s pioneering work model recovery, Dargush’s ability to bring diverse models to analogous situations, and Alesch and Holly’s longitudinal and cross-sectional study of communities following disasters provide an exceptional opportunity to explore the potential for self-organizing systems models to help us understand and explain post-event responses in communities.

**Progress to date:** *(If applicable, a short description of achievements in previous years. Clearly distinguish progress achieved in the past year, i.e., accomplishments from April 1, 2004, to March 31, 2005.)*

Professor Chang has reported her MCEER research findings regularly, but since this collaboration would be a new activity, no reports exist for prior years. Alesch, however, presented two papers on this subject in Japan in January 2005. One dealt with conceptualizing post-event behaviors in communities in terms of self-organizing systems. The other addressed hidden losses from extreme events, focusing on damage to critical socio-economic relationships.

**Role of Proposed Task in Support of Strategic Plan:** *(Describe how the effort will make a unique, useable contribution to the MCEER strategic plan.)*

This task is aimed at providing “post-graduation” support for MCEER both in terms of an NSF grant and in terms of developing a cutting edge competency in modeling what happens in
communities following an extreme event. The project relates to MCEER’s multi-hazard and infrastructure focus. It offers the potential for achieving a breakthrough in the development of a comprehensive theory of community recovery with implications for hazard mitigation and recovery strategies.

**Task Integration:** *(Describe how the work performed interfaces with other tasks and researchers funded by MCEER.)*

Professor Chang has agreed to work with Alesch, Dargush, and Holly to exchange papers, engage in learned discussions to identify and explore issues in understanding recovery processes, and to seek opportunities for future collaboration. Professor Chang will be included in the proposal to NSF that is an intended outcome of this activity. This research also builds on research by Alesch and Holly and supported by the Public Entity Risk Institute over a five year period.

**Possible Technical Challenges:**
None are foreseen at this time.

**Anticipated Outcomes and deliverables:** *(Also indicate those of particular benefit to IAB members and other end users.)*

1. A proposal to the National Science Foundation for support for three years to further this research.
2. One or more articles in refereed journals.
3. A working paper or monograph suitable for publication by MCEER.

The potential payoffs from this research are significant. First, the self-organizing system models can add a spatial dimension to models of what happens in communities following an extreme event. This means that the approach may also contribute significantly to the theory of urban growth and change—an area with little theoretical advance in the past five decades.

Second, to the extent that we learn that recovery is largely a function of loss to the built environment, the case for mitigation becomes extremely strong; depending on mitigation, events of the same magnitude will cause more or less damage.

Third, the approach facilitates the introduction of non-linear, chaotic elements in

**Potential end-users beyond academic community:** *(IAB members and others.)*
None foreseen from the immediate task. We expect persons and organizations outside academia to use the results of the research if it is funded by NSF.
the recovery process; e.g., Kobe rebuilt its port, but it moved from one of the busiest ports in the world to the 31st busiest and will probably never recover its prior position, all because of what happened elsewhere while the port was down.

Fourth, we think the research will suggest important criteria for governmental “seeding” to stimulate and speed recovery.

Educational outcomes and deliverables, and intended audience:

None anticipated from this first year of activity and development of the NSF proposal.

Project Schedule and Expected Milestones for the Project: (Milestones and estimated time of achievement; e.g., Fall, Spring, Summer.)

Quarter 1. Build on existing materials to develop narrative and statistical descriptions of three demonstration sites, including pre-event system characteristics, direct losses from the extreme event, and post-event system characteristics.

Quarter 2. Develop a basic model lodged in self-organizing systems theory and apply to one or more demonstration sites. Conduct working session of Alesch, Dargush, Chang, Holly (and possibly others) to identify and explore issues and concepts, and to press toward greater understanding of what happens in communities following extreme events that result in varying levels of loss.

Quarter 3. Evaluate the general applicability of the self-organizing systems model and concepts to the challenge of understanding what happens to communities following extreme events and to recovery theory.

Quarter 4. Develop a proposal to the National Science Foundation for three-year support.

Team Members: (If known, provide names of team members associated with project including project leader, other faculty and their departments, undergraduate students, graduate students, postdoctoral students, industrial participants.)

D. Alesch, G. Dargush, S. Chang, and James Holly.

Professor Chang is not seeking support under this project but has agreed to work with other members of the team to advance MCEER’s collective understanding of recovery processes. Dr. Holly would be a new participant in MCEER. He holds a BS and two masters degrees in engineering, an MBA, and a Ph.D. in Communication from the University of Illinois. He has worked with Alesch for more than a decade on attempting to understand the long term consequences of extreme events on communities, post-event behaviors of small businesses and not-for-profits, and impacts on local government. An NSF-formatted curriculum vita is attached.

Possible Direction of Work in Subsequent Years:

If the NSF proposal is funded for three years, we expect future work to continue without need of
MCEER’s financial support. The results of that research project should open avenues for additional funded research focusing on recovery theory and the impact of infrastructure loss mitigation on recovery.

Multi-Hazard Statement:

a) (Conceptually describe in 200 words or less how some of the work you are conducting as part of your MCEER Year 9 research task can be exported/applied to other natural or man-made hazards including multi-hazard research.)

   This work is focused entirely on multiple perils. The sites selected for preliminary modeling suffered hurricane, flood, earthquake, tornado, and terrorist attack. The intent is to create a model to help with understanding of what happens in communities following one or more extreme events; it is generally applicable across hazards.

b) If you are seeking supplemental multi-hazard funding, describe the multi-hazard milestones that you plan to complete as part of your Year 9 research.

These are fully integrated into the Milestone Section.