## MCEER RESEARCH TASK STATEMENT

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<tr>
<th>Overarching Activities</th>
<th>Budget:</th>
<th>Yr 8 Assigned</th>
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<td>Project Number: 8.03</td>
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### Task Title
Direct Losses, Social Impacts, and Community Resilience: L.A. Lifelines

### Investigator
Stephanie Chang

### Institution
University of British Columbia

*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.)

This project aims to develop a loss model and related measures of community resilience for the Los Angeles lifeline study. It focuses on social and economic dimensions of resilience. In Year 7, the L.A. loss model is being refined by undertaking preliminary investigation of performance objectives (from the perspective of utilities), modeling impacts on hospitals, and integrating with related MCEER research. The Year 8 effort will investigate lifeline performance and resilience from the perspective of the broader community. Its goal is to recommend a procedure for developing resilience measures and objectives based on community stakeholder participation.

### Problem Description and Research Approach of Proposed Work for Year 8:
(Detailed description of research to be conducted and methodology to be used.)

Over the last several years, MCEER has been developing sophisticated models of lifeline damage, outage, and socio-economic disruption and loss that indicate community resilience in earthquakes. In addition, important advances have been made in the proposal of conceptual and measurement frameworks for community resilience. This research is leading toward the development of a decision support platform for critical lifelines that addresses seismic resilience in its technical, organizational, societal, and economic dimensions.

A critical research need that has emerged concerns the definition and measurement of lifeline performance objectives and, more broadly, community resilience objectives. These objectives play a central role in MCEER’s resilience framework and in the use of the lifeline models to implement the framework for decision-support. For example, objectives have been proposed of the form “x% of households have electric power within y days after the earthquake with z% probability” (Bruneau et al., 2003; Shinozuka and Chang, 2004). Objectives can be defined in terms of both system robustness and restoration rapidity, as illustrated by \( r^* \) and \( t^* \), respectively, in Figure 1. Objectives stated in this form can be readily integrated with MCEER’s loss modeling approach to assess the resilience improvement benefits of seismic mitigations and to evaluate how much mitigation is required, as demonstrated with hypothetical objectives for the Memphis Light, Gas, and Water case (Chang and Shinozuka, 2003). However, because resilience objectives represent a new concept, guidelines are needed for implementing and quantifying them in actual case study applications.
MCEER investigators have begun to explore this research area, primarily from the perspective of utilities. Resilience and performance objectives concepts have been introduced in meetings with LADWP managers (i.e., July 2003 meeting at LADWP attended by O’Rourke, Shinozuka, Rose, and Chang; MCEER annual meetings). A workshop to be held at LADWP is planned for May 2004. This workshop will bring together LADWP managers for both water and electric power systems, MCEER social science and lifeline researchers, and some emergency responders and members of the community to discuss and begin articulating performance objectives.

Complementing and building on this workshop, the current research task in Year 8 will focus on the question of how lifeline performance objectives can be defined with the input of the broader community. While the workshop is expected to clarify objectives from the perspective of LADWP, this task investigates lifeline performance from the perspective of community stakeholders such as emergency response providers, health care providers, elected officials, businesses, and the population at large. The issue of how to most effectively engage community stakeholders in defining performance objectives is a very complex and critical one that should be addressed in a systematic manner. The Year 8 effort will (1) conduct an extensive literature review, (2) identify relevant approaches, and (3) recommend a procedure for the LADWP case.

The literature review will investigate participatory planning approaches for addressing problems of environmental risk. This review will begin with studies that have been done on “acceptable risk” in the earthquake field, with an emphasis on participatory planning. However, it will also cover a broader literature pertaining to other types of natural disasters, as well as other types of environmental risks (e.g., hazardous materials siting, ecosystem protection, etc.).
Several successful model approaches of participatory planning will be identified from this literature and explored in some detail.

The objective will be to develop a systematic approach for the LADWP case for involving stakeholder participation in defining community performance and resilience objectives. This approach will address such questions as: How are stakeholder groups to be identified and representatives recruited? What participatory environment (e.g., interviews, focus groups, workshops, etc.) are most appropriate? How should the interaction between researchers and stakeholders (e.g., in a workshop setting) be structured? How should the discussions be framed? How should computer-based models (i.e., MCEER’s integrated lifeline model) be used in this setting? How should technical information be presented? In addition, the effort will also develop some supporting tools, such as example workshop agendas or questionnaires.

The review, together with recommendations in the LADWP case, will be summarized in a technical report. It is intended that this groundwork investigation in Year 8 would lead to an actual exercise (e.g., a workshop) in Year 9. In contrast to the May 2004 workshop, this exercise would focus on community stakeholders, apply participatory planning methods based on the literature review, and utilize results of MCEER’s integrated lifeline model for L.A. (which will be largely completed by then) to facilitate deliberations.

This research will benefit from and build on recent research by K. Tierney and others on perceptions of earthquake impacts and loss-reduction policy preferences among community residents and opinion leaders. That research (supported by NSF) conducted a community survey and focus group exercises in Oakland, California, and investigated, among other questions, the issue of acceptable levels of performance, disruption, and loss.

References:
Chang, S.E. and M. Shinozuka. 2003. “Measuring Improvements in the Disaster Resilience of Communities,” manuscript. (under journal review)

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

To the P.I.’s knowledge, MCEER researchers have developed the only existing models that evaluate the economic disruption impacts of electric power and/or water outage in earthquakes. This work is also innovative in modeling earthquake risk in terms of community resilience, rather than simply in terms of expected loss. The PI is not aware of any work being done outside of MCEER on systems performance objectives for utility lifeline systems in the earthquake context.
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, 2003, to March 31, 2004.)  

Efforts in previous years, under the Memphis Lifelines and the Loss Estimation tasks, produced an integrated engineering-economic model of losses due to water outage. Within the last year, to complete work on Memphis, the model was refined to evaluate outcomes in terms of community resilience. It was then applied to evaluate the resilience improvements of two retrofit strategies: (1) pump station retrofits that were actually undertaken by MLGW and (2) a hypothetical, alternative set of pump station retrofits. Results showed that while the hypothetical retrofits provided more resilience benefits, they were insufficient to meet specified resilience objectives. A manuscript on this work (by Chang and Shinozuka) has been submitted to *Earthquake Spectra* as a follow-on article to the Bruneau et al. (2003) piece on resilience concepts.

Substantial progress has been made on developing a parallel model for Los Angeles. The L.A. community resilience model incorporates two significant refinements from the Memphis model: (1) It is a multi-source loss model. Rather than evaluating impacts from water outage alone, it models business impacts deriving from simultaneous water loss, electric power outage, and building damage. This advance is not only important conceptually, but will also facilitate integration of MCEER’s power and water system analyses. While the Memphis model was based on K. Tierney’s business surveys for Northridge and Memphis, the L.A. model is based on her surveys for Northridge and Loma Prieta. (2) The L.A. model simulates impacts at the level of the individual business. In Memphis, simulation was performed at the level of the analysis zone (a subdivision of census tracts). This refinement not only makes the modeling more consistent with the underlying data, it also improves its implementation as a probabilistic model. The L.A. model will be applied to a 1% sample of L.A. County businesses, which is in the process of being developed from a Dun & Bradstreet database of businesses.

The refined model has been developed and was successfully tested in prototype in Excel. It is now being programmed in C++.

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

The proposed research will support MCEER’s strategic plan by contributing toward the next generation lifeline system, which is critical for earthquake resilient communities. Specifically, the research contributes towards a systems model that promotes a comprehensive assessment of lifeline disruption risk in earthquakes. It develops a model for evaluating social and economic resilience impacts of loss reduction strategies, including engineering technologies, that MCEER is developing for water and power systems. This model will help utilities and the communities they serve to make rational decisions about the allocation of resources necessary to achieve community goals in earthquake resilience.

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

This research focuses on performance and resilience objectives, a key element of the lifelines decision support platform that is being developed by MCEER researchers (O’Rourke, Grigoriu,
Shinozuka, Davidson, Rose) in the LADWP demonstration. This research will also be coordinated with A. Rose’s work on defining community level performance criteria from a customer prioritization standpoint and K. Tierney’s work on perceptions of earthquake impacts and loss-reduction policy preferences.

### Possible Technical Challenges:

Translating participatory planning models from other fields of application to the earthquakes/lifelines area. Gaining LADWP managers’ acceptance of the idea of community-based performance objectives.

### Anticipated Outcomes and deliverables:

(Also indicate those of particular benefit to IAB members and other end users.)

- Technical report (summarizing literature review, relevant participatory planning models, and recommendations for LADWP case).
- Recommended approach for developing community-based performance objectives in LADWP demonstration (including implementation details and example supporting tools, such as questionnaires).

### Potential end-users beyond academic community:

(IAB members and others.)

- LADWP, EBMUD, and other utilities.
- Urban planners.

### Educational outcomes and deliverables, and intended audience:

- Training of 2 graduate students.
- In addition, the technical report can provide guidance to other utilities and communities seeking to define lifeline performance objectives with community input.

### Project Schedule and Expected Milestones for the Project:

(Milestones and estimated time of achievement; e.g. Fall, Spring, Summer.)

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<tr>
<th>Winter 2005</th>
<th>Initiate literature review.</th>
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<tr>
<td>Spring 2005</td>
<td>Complete literature review.</td>
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<tr>
<td>Summer 2005</td>
<td>Identify relevant participatory planning models for LADWP case. Develop recommended approach for LADWP case.</td>
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<tr>
<td>Fall 2005</td>
<td>Develop example tools, e.g., questionnaires. Write technical report.</td>
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<td><strong>Team Members:</strong> (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.)</td>
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<td>S.E. Chang, Principal Investigator</td>
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<td>2 graduate research assistants, to be determined</td>
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<th><strong>Possible Direction of Work in Subsequent Years:</strong></th>
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<tr>
<td>Implementation of recommended approach for LADWP case, e.g., workshop to develop community-based performance objectives.</td>
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