Final Project Summary — PEER Lifelines Program

Project Title—**ID Number**	*Earthquake Risk Decision-Making in Lifeline Organizations*—**604**		
Start/End Dates	6/1/01 – 4/30/02	Budget/ Funding Source	$173,972 / FEMA
Project Leader (boldface) and Other Team Members	**Seaver,** Robershotte, and Baker **(Battelle – Pacific Northwest Division)**		

1. Project goals and objectives

In areas with earthquake potential, preparing for and responding to earthquakes is a significant responsibility of lifeline organizations. The decisions made by these organizations about how to manage and mitigate the risk of earthquakes are vital to both the organizations and the communities they serve. The overall purpose of this research is to improve the understanding of how lifeline organizations make decisions about earthquake risk, identify critical issues and areas for potential improvement, and transfer general recommendations about decision-making to a broad range of lifeline organizations. This report describes the initial pilot phase of the research. The purpose of the pilot effort is to test data collection and analysis methods and to provide the participating organizations, the Pacific Gas & Electric Company (PG&E) and California Department of Transportation (Caltrans), with preliminary analysis on earthquake risk decision-making in their organizations.

This pilot study is primarily descriptive. It is an attempt to better describe and characterize earthquake risk mitigation decisions. It focuses on earthquake risk mitigation decisions in the lifeline organizations that are leaders in this area, and on the methods for studying these decisions. The pilot study is intended to identify key research issues and develop and assess the research methods to provide the basis for designing and conducting subsequent phases of research not to come to final conclusions.

2. Benefits of the results of this project to develop technologies and protocols to mitigate the vulnerability of electric systems and other lifelines to damage directly and indirectly caused by earthquakes. Also, benefits to develop assessment techniques to evaluate damage to electric systems caused by earthquakes and to assess fiscal impacts due to the loss of electric service to the community.

External events drove the earthquake risk decision-making programs in both organizations. In general, most decisions were made either explicitly or implicitly in regard to political considerations and influences. For both organizations, the decision-makers did not generally get involved in the details of the issues. No specific tradeoff analysis or cost-benefit approaches were deemed necessary or relevant. It was clear that general organizational objectives and goals included a strong safety culture and responsibility towards the public. Generally, a broad set of mitigation options were considered and a salience bias was clearly in evidence. Relevant criteria were generally considered. Both organizations learned and improved their prioritization decision methodologies as time went on. In general, most of the criteria were explicit. For the two organizations, tradeoffs were difficult to assess in any meaningful way and uncertainties associated with technical information were generally not directly communicated to the decision-makers.

Beyond protecting the public safety and insuring continuity of service one measure of success of the earthquake risk decision-making program for PG&E is if the costs are allowable and can be passed on in the rate base. For Caltrans, success beyond safety is achieved by pleasing the communities served and acceptance by the elected officials. Overall, by these measures, both organizations' programs are clearly successes. The major difference found in this study between the two organizations was the involvement and influence of many more organizations and stakeholders in Caltrans decisions.

3. Brief description of the accomplishments of the project

Earthquake risk decision challenges differ only in a matter of degree from other non-earthquake related complex business decisions. The same decision elements are present but they are usually more daunting in earthquake risk decisions. Often, too little mitigation action is taken prior to major earthquakes and then decision-makers may tend to overspend on mitigation efforts after the earthquake. Cost benefit analysis as part of a comprehensive decision analysis to maximize expected utility would be a logical approach and the preferred way to address earthquake risk mitigation decisions. However, this has not been done in the past.

Earthquake risk management actions are most successful soon after actual earthquakes. Determining and communicating additional benefits from the mitigation efforts can help justify a program/project, particularly with some stakeholders. Organizations should focus as much as possible on the lifeline "systems" rather than the individual components. Also, R&D efforts are important and significantly contribute to successful earthquake risk decisions. Since retrofitted bridges and buildings look and function the same as before mitigation efforts, it is

difficult for the public to see the benefits. Thus, the public needs to be educated and frequently reminded of the value of such programs/projects. Probabilistic rather than deterministic analysis of earthquake hazards produces more complete and accurate results and is an effective part of performance-based earthquake engineering.

An organizational champion for earthquake risk management is critical as is the organizational culture to nurture that champion. Peer reviews of earthquake risk programs are essential. In addition, the lifeline organization should participate in cross-organizational technical groups to share up-to-date information and experiences. A core group of professionals within the organization should be identified as the technical lead for earthquake risk. Lifeline organizations should make full use of external organizations to support earthquake risk management programs/projects and develop close working relationships with Federal agencies heavily involved in the program/project. Communications with external parties need to be carefully managed and external advisory groups should be used to enhance credibility and technical accuracy.

It is important to note that key earthquake engineering champions and staffs in both organizations should be appreciated and commended for their extraordinary performance over many years and against great odds. To develop, champion and sustain the earthquake mitigation efforts in both companies was not without problems but was no small feat. PG&E and Caltrans have proven they are indeed leaders in their field with much to teach both lifeline and other organizations.

4. Describe any instances where you are aware that your results have been used in industry

Results not available yet.

5. Methodology employed

The methodological approach developed for the pilot study was the product of several workshops involving the project team, the participating representatives from the sponsoring organizations, and a panel of academic experts. The pilot study approach focused on specific past earthquake risk decisions in PG&E and Caltrans. These decisions were selected to cover a wide range of earthquake risk mitigation decisions. A decision analysis framework was used to identify key characteristics of these decisions that should be described and analyzed. In-depth interviews with program and project participants were conducted to obtain the information about the decisions. For each organization three decisions were studied. The PG&E decisions were: the establishment of the earthquake risk management program; the retrofit of the San Francisco Headquarters building; and the retrofit of the Lake Almanor and Butt Valley dams. The Caltrans decisions were: the establishment of the bridge seismic retrofit program; the retrofit prioritization program; and the replacement and retrofit of the Carquinez Bridge.

6. Other related work conducted within and/or outside PEER

None.

7. Recommendations for the future work: what do you think should be done next?

PEER should pursue a deductive theory driven approach to Phase II. The many significant questions that arose after examining the pilot phase interview data beg to be more fully answered in Phase II and include: How should earthquake risk mitigation decisions be made in lifeline organizations and how do these concepts translate to organizations confronting different environmental contexts? What is acceptable risk? What is meant by performance based decision-making? How can earthquake risk champions encourage decision-makers to seriously assess earthquake risks in the absence of a major quake? How important is it that top-level decision-makers understand risk probabilities and uncertainty issues and how can engineers better communicate with these decision-makers? How are alternatives generated and evaluated and what can be done to position organizations to be able to more effectively respond to a salient earthquake event? A comprehensive theoretical approach appears to offer the best method to answer the unanswered questions remaining from the descriptive/inductive pilot Phase I approach. This continued research offers significant benefits, not only to lifeline organizations but to any organizations facing low probability high consequence events such as our countries' current efforts to defend critical infrastructure against terrorist acts.

8. Author(s), Title, and Date for the final report for this project

Robershotte, M. A., Seaver, D. A., and Baker, K. A., Earthquake Risk-Decision Making in Lifeline Organizations Phase I (Pilot Study) Report, March 2003