

9. Recommendations for Further Work

9.1 Introduction

The ATC-25 project has raised a number of questions and indicated areas in which knowledge is inadequate or nonexistent with respect to the impact of lifeline disruption due to earthquake. Following is a discussion of recommendations for further research and other efforts. This list is not meant to be all inclusive but rather an overview of some of the more important issues that should be pursued.

9.2 Lifeline Inventory

This project has initiated the development of a comprehensive national lifelines inventory database. Completion of this monumental task will require many person-years of effort. Organizations such as the Federal Emergency Management Agency, Department of Transportation, and American Society of Civil Engineers Technical Council of Lifeline Earthquake Engineering are encouraged to build on the work performed in this project, develop standards for complete lifeline inventories, and coordinate the acquisition of the needed additional and updated data from various lifeline owners. Capacity data in the National Petroleum Council's oil/gas transmission line inventory is an example of the kind and extent of information that is needed in lifeline inventory databases. An integral part of any project to augment the existing ATC-25 lifeline database should be its wide availability in the public domain.

9.3 Lifeline Component Vulnerability

This project employed lifeline component vulnerability functions developed in the ATC-13 project (ATC, 1985) on the basis of expert opinion obtained by surveys. While the ATC-13 expert-opinion data are extremely useful, comprehensive information based on hard field data would provide an improved basis for estimating lifeline vulnerability. We recommend a major effort to acquire data on lifeline seismic performance and damage, and conduct analysis towards the development of improved component vulnerability functions. This effort

should also investigate lifeline recovery data, and incorporate the extensive experience realized during the 17 October 1989 Loma Prieta, California, earthquake, as well as from other damaging earthquakes.

9.4 Seismic Hazard Data

The project has uncovered the relative paucity of seismic hazard models and resources at the regional/national scale. Only two models are available, those of Evernden and Thompson (1985) and Algermissen et al. (1990), the latter of which does not incorporate a soils database. While a nationally agreed upon seismic hazard model may be desirable, this is less of a priority than the need for a digitized soils database. That is, existing models (e.g., attenuation relations, seismicity databases, seismotectonic models) are sufficient for a number of site-specific purposes, and can be expanded to regional modeling, given an adequate soils database. We suggest that the U. S. Geological Survey develop, or coordinate through the various states' Office of Geologists, a series of digitized soils/geologic databases.

9.5 Economic Analysis and Impacts Data and Methodology

This project has presented a rational comprehensive model for the estimation of the economic impacts due to lifeline disruption. Many steps of the process necessarily involved approximations and limited analyses. We recommend further research, especially in economic areas such as:

- Economic impacts associated with lifeline disruption,
- Second-order economic effects (e.g., interaction between lifelines, such as the effect of disrupted electric power on the water supply),
- Elasticities of demand, or substitution of a lesser disrupted lifeline (e.g., fuel oil) for a more disrupted lifeline (e.g., natural gas),

- Inter-regional impacts (e.g., economic impacts in New York due to disruption in California), and
- So-called "benefits," such as increased economic activity associated with repair, or replacement of older equipment with new technology.

Lastly, we note that this study did not address environmental consequences associated with lifeline disruption, especially the potential for oil spills from broken pipelines in the nation's waterways following a New Madrid event. Investigation of this issue is critically important.