The National Earthquake Hazards Reduction Program at Twenty-Five Years: Accomplishments and Challenges -- Summary of a Workshop, February 20, 2003, Washington, DC

A Summary to the Natural Disasters Roundtable by Ellen de Guzman, The National Academies

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THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM AT TWENTY-FIVE YEARS: ACCOMPLISHMENTS AND CHALLENGES

SUMMARY OF A WORKSHOP
FEBRUARY 20, 2003
WASHINGTON, DC

A SUMMARY TO THE
DISASTERS ROUNDTABLE

BY

ELLEN DE GUZMAN
NATIONAL RESEARCH COUNCIL

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FOREWORD

The Disasters Roundtable (DR) seeks to facilitate and enhance communication and the exchange of ideas among scientists, practitioners, and policymakers concerned with urgent and important issues related to natural, technological, and other disasters. Roundtable meetings are held three times a year in Washington, D.C. Each meeting is an open workshop focused on a specific topic or issue selected by the DR Steering Committee. For upcoming meetings, please visit http://www.nationalacademies.org/disasters.

The Disasters Roundtable Steering Committee is composed of five appointed members and sponsoring ex-officio members. The appointed members are William H. Hooke, chair, American Meteorological Society; David Applegate, American Geological Institute; Ross B. Corotis, University of Colorado, Boulder; Ann-Margaret Esnard, Cornell University; Ellis M. Stanley, Sr., Emergency Preparedness Department of the City of Los Angeles; Richard T. Sylves, University of Delaware; and Susan K. Tubbesing, Earthquake Engineering Research Institute, Oakland. The ex-officio members are Lloyd Cluff, Pacific Gas & Electric; Dennis Wenger, National Science Foundation; Timothy A. Cohn, US Geological Survey; Stephen Ambrose, National Aeronautics and Space Administration; Margaret Lawless, Federal Emergency Management Agency; Deborah Dietrich, US Environmental Protection Agency; James Russell, Institute for Business and Home Safety; and Helen Wood, National Oceanic and Atmospheric Administration. The DR staff are William Anderson, director; Patricia Jones Kershaw, staff associate, and Kemi Yai, project assistant.

This document presents the rapporteur's summary of the workshop discussions and does not necessarily reflect the views of the roundtable members or other participants. Thanks to Professor Richard Sylves of the University of Delaware for providing his notes from the workshop.

For more information on the Roundtable visit our website: http://national-academies.org/disasters or contact us at the address below.

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This summary has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published summary as sound as possible and to ensure that the summary meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this summary:

Thomas Anderson, Consultant, Washington, DC

Walter Hayes, University of North Carolina, Charlotte

John R. Harrald, George Washington University, Washington, DC

The review of this summary was overseen by Richard N. Wright. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this summary was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this summary rests entirely with the author and the institution.

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THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM AT TWENTY-FIVE YEARS: ACCOMPLISHMENTS AND CHALLENGES

ABSTRACT

The purpose of the 7th Disasters Roundtable workshop, held on February 20, 2003, was to review the accomplishments and challenges of the National Earthquake Hazards Reduction Program (NEHRP) on its 25th anniversary. Many program accomplishments were noted, including advances in earthquake monitoring and mapping, in research resulting in the design and construction of seismic-resistant buildings and lifelines in risk-prone areas, and in research enabling the development of more effective emergency response and recovery systems. These and other achievements were made possible in part because NEHRP furthered the integration of earthquake science and earthquake engineering and worked with stakeholders throughout the nation. Despite such accomplishments, it was also noted that many challenges still lie ahead. Challenges discussed included the need to bridge the gap between research and applications, to overcome decreased funding levels, and to continue to attract support in an era in which homeland security has become a dominant concern for decision makers and others. Because of the time constraints imposed by a one-day meeting, some accomplishments and challenges were considered at length, while others could only be briefly mentioned in preparation for further discussion at other venues.

INTRODUCTION

The Disasters Roundtable[1] (DR) held its seventh public workshop on February 20, 2003 at the National Academy of Sciences building in Washington, D.C. At this one-day workshop, accomplishments of the National Earthquake Hazards Reduction Program (NEHRP) over the last 25 years were reviewed and the present and future challenges of the program were discussed.

The 1977 Earthquake Hazards Reduction Act (Pub. L. 95-124) was created to reduce risks of life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program. A series of devastating earthquakes, including the 1964 earthquake in Prince William Sound, Alaska and the 1971 San Fernando, California earthquake, resulted in

[1] The National Research Council defines a "roundtable" as a type of convening activity of the National Academies that provides a means for representatives of government, industry, and academia to gather periodically for the identification and discussion of issues of mutual concern. In contrast to National Research Council study committees and other committees of the National Academies, roundtables are intended solely to enable dialogue and discussion among key leaders and representatives on a particular issue. They provide a valuable forum for exchanging information and for the presentation of individual views. However, because roundtables are not subject to institutional requirements concerning conflicts of interest, composition, and balance that apply to NRC committees, roundtables are prohibited by the National Academies from providing any advice or recommendation. This paper presents the rapporteur's summary of the forum discussions and does not necessarily reflect the views of the roundtable members or other participants.

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loss of life and cost millions in property damage. At this time there was also growing excitement and optimism among scientists about the feasibility of short-term earthquake prediction (NRC, 1976). In 1976 the President's Office of Science and Technology Policy (OSTP) formed the Newmark-Stever[2] Committee, which was tasked to formulate a program to study and respond to seismic hazards in Southern California and later expanded to include issues on the nationwide earthquake threat. Among the committee's recommendations was the establishment of a national program that, underpinned by research, would lead to the reduction of earthquake risks to life and property. Originally, the law authorized the U.S. Geological Survey (USGS) and the National Science Foundation (NSF) to participate in NEHRP. In the 1980 reauthorization, the Federal Emergency Management Agency[3] (FEMA), which was formed in 1979, was designated as the lead agency (Public Law 96-472, October 19, 1980) to coordinate activities of the program. The National Institute of Standards and Technology (NIST) was also designated as a participating agency. All four agencies (USGS, FEMA, NIST, and NSF) currently make up NEHRP. The program is charged with furthering research on earthquake science, earthquake engineering and social science research related to earthquakes, and implementation efforts related to improving building and infrastructure performance during earthquakes and more effective emergency response, recovery and reconstruction. NEHRP remains the federal government's primary effort to reduce earthquake risks and has been reauthorized by Congress eight times since 1977.[4] NEHRP is up for reauthorization again in 2003.

The DR steering committee selected an interdisciplinary group of speakers and panelists (See Appendix A for the agenda, Appendix C for speakers bios) for this one-day workshop to discuss the accomplishments of the program in the past quarter of a century and address the issues and challenges NEHRP faces in the light of reauthorization, budget constraints, changing priorities of government, advances in science and technology, and the changing social landscape. Approximately 100 people participated in the workshop (See Appendix B for a list of registrants).

PERSPECTIVES OF NEHRP AGENCIES

This session was a moderated discussion featuring high level policy makers in the NEHRP agencies focusing on such issues as how the program fits into their agencies' missions, program accomplishments in the past 25 years, and future challenges.

Peter Freeman, Assistant Director of the Computer Information Sciences and Engineering Directorate (CISE), **National Science Foundation** (NSF), explained NSF's role in NEHRP as one of investing in people, ideas, and technologies. As part of its contribution to NEHRP, NSF supports earthquake research at the Multidisciplinary Center for Earthquake Engineering Research at the State University of New York at Buffalo, the Mid-America Earthquake Center at the University of Illinois at Urbana-Champaign, the Pacific Earthquake Engineering Research Center at the University of California at Berkeley, and the Southern California Earthquake Center at the University of Southern California. Other important earthquake related investments by NSF include EarthScope, which is a network of geophysical instruments and observatories, and the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) program, a nationwide distributed system of laboratories for collaborative experimental earthquake engineering research that is scheduled for full operation in 2004.

[2] Nathan Newmark, a world recognized leader in earthquake engineering research from the University of Illinois, and Guyford Stever, President Gerald Ford's science adviser (1974-1977), and head of the National Science Foundation oversaw the preparation of the resulting report (USGS, 1996).

[3] FEMA has been organized under the new Department of Homeland Security. FEMA interacts with the new science and technology directorate within the Department of Homeland Security.

[4] See Appendix A of OTA, 1995 for discussion of changes in the program. Also see NSTC, 1996 for a brief summary of principal accomplishments of NEHRP.

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Freeman emphasized that the biggest challenge of earthquake science and engineering at NSF is the effective integration of earthquake relevant research and tools across its directorates: engineering, natural and physical sciences, social and behavioral science, and computer information science and engineering. Part of the annual budget of CISE is dedicated to researching information technology models related to extreme events. As part of its NEHRP activity, NSF funds post-earthquake investigations. This has provided needed experience for responding to willful disasters the nation now faces. Immediately after the September 11 terrorist attacks, NSF directorates issued more than a dozen awards for projects to examine various aspects of the disaster. Subsequently, additional awards were made and of the current total of 137 awards, 16 were for studies on critical infrastructures funded by CISE. Freeman explained that there is a need for greater integration of research on earthquakes and that improved data collection on the subject will not have maximum impact unless advanced computing technology and computational software are applied to manage and process these data. Further, there is a need for improved computing and communication capabilities to prepare for extreme events and for crisis management.

Arden L. Bement, Jr., Director of the **National Institute of Standards and Technology** (NIST) outlined ongoing NEHRP activities at NIST, such as that related to seismic design and construction standards, earthquake resistant construction, interagency committee coordination, and code evaluation activities. NIST is involved in both basic research and applied engineering. After a disaster, NIST's role is to determine which construction designs were successful and which construction designs failed. NIST works closely with its private sector industrial partners and stakeholders to help fill the technology transfer gap and to develop new technologies such as hybrid pre-cast concrete structural designs, which is being done in collaboration with both private industry and academia. Currently, there are about 120 projects at NIST that involve wide-ranging issues, including homeland security. Much of NIST's research experience is being directly applied to the investigation of the World Trade Center building performance following the September 11, 2001 attack. For example, among other things, the agency is providing information about bomb effects, which can shed light on the impacts of the loads on the building induced by the terrorist attack, and helping to review designs to rebuild at the World Trade Center site. NIST not only carries out research to improve and modernize building and fire codes but also dispatches field teams to disaster sites involving fire, earthquakes and other types of disaster agents.

Charles G. Groat, Director of the **U.S. Geological Survey (USGS),** reported that 5% (amount in 2002 dollars) of the USGS budget is dedicated to earthquake research. The mission of USGS is to advance earth science and to help minimize the effects of disaster, thus this mission supports the goals of NEHRP. Great leaps in technology have helped in the deployment of better seismographic detectors and in the development of better "ShakeMaps" (maps of shaking intensity from earthquakes) each of which helps improve disaster response. New scientific advances have greatly improved the ability of experts to measure and map earthquakes, process digital data and provide almost real-time analysis. For example, the NSF-funded EarthScope program coupled with the USGS's Advanced National Seismic System (ANSS) program is expected to make significant contributions to NEHRP. It is important to distinguish the two programs from each other. While the USGS-funded ANSS is being built as a nationwide network of at least 7,000 shaking measurement systems that will make it possible to provide real-time earthquake information and building and site responses, the NSF-funded EarthScope Program is a network that will attempt to apply modern observational, analytical and telecommunications technologies to investigate the structure and evolution of the North American continent and the physical processes controlling earthquakes and volcanic eruptions. Both programs are models for federal-state-university collaboration.[5] Groat pointed to a number of other accomplishments under NEHRP, including advances in hazard assessment and in paleoseismology

[5] For discussions of ANSS and EarthScope see boxes 6-1 and 6-2 of NRC, 2002.

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(the geologic study of the past behavior of active faults), the latter having extended the history of seismic events back thousands of years. Among the challenges facing NEHRP he noted were the need to operate in an environment in which homeland security is a dominant issue and the need to work extra hard to show the continuing significance of earthquake research and mitigation efforts. The upcoming NEHRP reauthorization hearing may provide an opportunity for showcasing the continuing importance of earthquake research and mitigation efforts. Giving necessary attention to earthquake prediction, which had cooled off for at least the last dozen years or so, was seen as another challenge facing NEHRP. Groat also emphasized the need for the USGS to have closer ties with social scientists, particularly economists, with the private sector, and with the disaster management community. (For an expanded summary of earth science accomplishments in hazard mapping see, Frankel et al., 2000 and Leyendecker et al., 2000).

Anthony S. Lowe, Administrator, Federal Insurance and Mitigation Administration, **Federal Emergency Management Agency** (FEMA), pointed to a number of accomplishments of NEHRP during the past 25 years, including advanced knowledge on how faults behave, the development of seismic building standards and guidelines, and advances in the research infrastructure as exemplified by the earthquake research centers and the development of the Network for Earthquake Engineering Simulation program. He indicated that because of its successes, NEHRP is relevant to countering the threat of terrorism as well as earthquakes, and therefore the program should operate in an all hazards environment.

Lowe sees a number of challenges facing NEHRP in the years ahead. He suggested that the program should become more performance based, with increasing attention given to implementation as well as research. Another challenge he sees is the need for NEHRP to give more attention to research coordination, and a group will soon be formed to consider this issue. Lowe sees funding as one of the most significant challenges facing NEHRP. He emphasized that there is a need for a separate budget for NEHRP activities in all of the four participating agencies. Lowe stressed that agencies should set forth a budget system that ties all dollars to missions and goals to address concerns regarding coordination, strategic planning, and other issues expressed by Congress. Despite the many accomplishments of the program, for the last 25-years NEHRP's funding has generally been flat (which is a 1/3 loss in value due to inflation). Thus the NEHRP budget has declined in constant dollars (see Figure 1) (NRC, 2002). If this budget pattern continues, NEHRP work will have to be more effective and efficient in order to produce worthwhile results. Lowe believes that NEHRP may provide a sound organizing principle for other programs in a similar budget predicament.

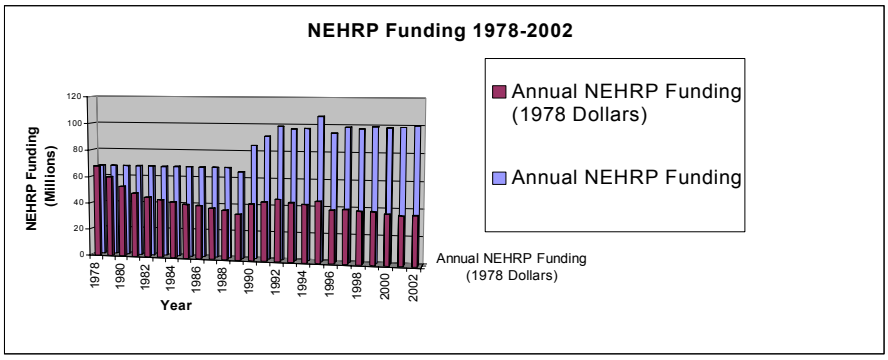

FIGURE 1 NEHRP Funding 1978-2002. (Presented by Craig Wingo, FEMA)

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PUTTING NEHRP TO USE

This session involved discussion on the accomplishments and challenges of implementing NEHRP from the perspective of private sector and government stakeholders.

Ellis M. Stanley, Sr., General Manager of the **Emergency Preparedness Department of the City of Los Angeles**, discussing his department's goal of making Los Angeles more disaster resistant, underscored the importance of partnerships with local communities to help communities better understand their role in earthquake preparedness. Assisting communities to have a better understanding of their earthquake risks and formulate options for mitigation is one of NEHRP's most promising implementation activities (OTA, 1995). The Federal Emergency Management Agency works with community redevelopment efforts in Los Angeles to build a model for earthquake preparedness and mitigation. The initiatives of FEMA and California's Citizens Corps have also advanced this cause, along with local chapters of the American Red Cross and the Allstate Insurance Company. Aside from NEHRP, the city also collaborates with private institutions on earthquake related safety. The Institute for Business and Home Safety, a major private insurance company supported organization, has also helped promote non-structural earthquake hazard mitigation in Los Angeles.

An important part of the Los Angeles Emergency Preparedness Department's program is to examine building codes, restrict unsafe building activity, and identify high-risk structures—based on NEHRP Handbook for the Seismic Evaluation of Existing Buildings. They use support tools such as HAZUS for computer simulation of earthquake damage, ETEAM simulation maps, and GIS decision analysis. The department's Community Emergency Response Teams train people at the local level, by supporting first responders, aiding disaster victims, and engaging in non-emergency project work. The department also uses incident management approaches and corporate information sharing (e.g., traffic and weather) to improve emergency preparedness.

Lloyd S. Cluff, Director of the Geosciences Department, **Pacific Gas and Electric** (PG&E) reviewed earthquake related achievements since NEHRP's creation in the areas of paleoseismic investigations, earthquake forecasting and ShakeMaps, national hazard maps, characterizing surface fault rupture effects and near ground motions, and regional hazard assessments. He noted that one accomplishment of NEHRP is its lifeline (i.e., those essential utility and transportation systems that serve communities across all jurisdictions and locales) research efforts (American Lifelines Alliance, 2003). For example, using the results of NEHRP research, the USGS Working Group on California Earthquake Probabilities is able to move away from short-term predictions and to make regional earthquake probability forecasts (see Figure 2). Figure 2 shows a 70 percent probability of earthquake occurrence in the San Francisco Bay region and more intensely in the areas of Hayward and Rodgers Creek faults, which is part of PG&E service area. Cluff emphasized that PG&E recognizes the importance of public-private partnerships in providing seismic safety. PG&E, under a Cooperative Research and Development Agreement (CRADA) on earthquake hazards with USGS, has integrated its strong motion instruments with USGS' ANSS. PG&E also participates in the Pacific Earthquake Engineering Research Center's Lifelines User-Driven Research Program[6] and the FEMA-sponsored American Lifelines Alliance[7]. Along with other corporations, PG&E has provided funding support for earthquake disaster reduction efforts to help offset the NEHRP budget erosion caused by inflation.

[7] Other members include USGS, NIST, the US Bureau of Reclamation, Federal Highway Administration, wastewater organizations, telecommunication organizations, and the Michael Baker Corporation.

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Chris Poland, chairman and president of **Degenkolb Engineers**, traced the development and contributions of NEHRP efforts that are relevant to structural engineering related to both new and existing buildings. An example of the NEHRP sponsored process for the development of codes and guidance for structural engineering related to existing buildings can be mapped from American Technology Council (ATC) 14, "Evaluating the Seismic Resistance of Existing Buildings" to FEMA 178, "NEHRP Handbook for the Seismic Evaluation of Existing Buildings", to the third generation of evaluation technology in FEMA 310, "Handbook for the Seismic Evaluation of Buildings: A Prestandard". This process is used for most codes that are now being developed and has now accelerated the transfer of new knowledge into the practice. In discussing past NEHRP accomplishments, Poland noted that advanced analysis procedures for buildings have been developed. But much more work is needed, for example to stop strengthening buildings that do not need strengthening and focus on those that do need it. He also pointed to new structural systems have been developed and applied through NEHRP, leading to a reduction in the "brute strength method". Poland emphasized that there is a need to take a more holistic approach to seismic safety as "a matter of public welfare, which involves the potential for loss of life or injury, disruption of lifeline systems, and costs to insurers, property owners, and governments for earthquake losses and recovery" (EERI, 2003). In this regard, the NEHRP should also find ways to bridge the gap between the public and design professionals by understanding better the public decision making process and the role it plays in designing building that can repel damages. Poland suggested that it is now time to pick up the pace of activities because the vulnerability of the nation is growing. This will require practicing engineers working more closely with engineering researchers funded through NEHRP.

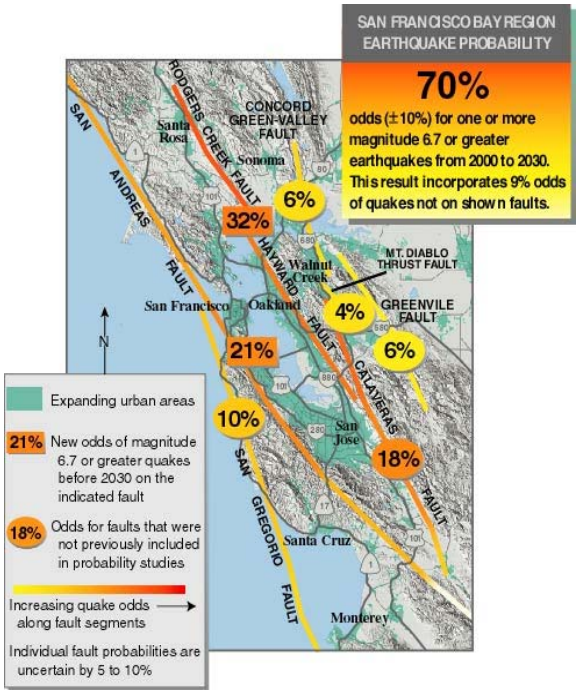

FIGURE 2 San Francisco Bay Region earthquake probability. Source: USGS Working Group on California Earthquake Prediction, 1999.

Clifford Roblee, Chief of Applied Geotechnical and Ground Motion Research at the **California Department of Transportation** (Caltrans), discussed some of the challenges facing NEHRP from the standpoint of transportation users of the information and technology generated by the program. Several NEHRP innovations have been diffused to and adopted by the transportation user community, but much remains to be done. The NEHRP program is generally appreciated for the quality of its researchers, facilities, and educational and training programs, but needs to improve the transparency of the overlapping agency roles and overcome the relatively insular nature of the earthquake research community. Roblee noted that the earthquake research community is a vibrant research network with a high level of scientific innovation and discovery. However, he also indicated that the applied engineering research community has generally not kept pace with the science; thus bridging the gap between researchers and practitioners is a major challenge for NEHRP. The NEHRP research community must shift from a 'science based' discovery-centered orientation toward a greater emphasis on 'applied-engineering based' research and implementation in order to rapidly improve mitigation. Applied research should focus on issues such as systematically gathering basic data used in existing models, verification and calibration of existing engineering models, consensus building and test applications. Roblee also identified the need to get end-users much more involved in NEHRP strategic planning and programmatic decisions to assure applicability to practice. He suggests identifying a

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percentage of research funding to be prioritized exclusively by end users rather than by researchers. He pointed to the Pacific Earthquake Engineering Research Center's Lifelines Program as a good example of how both researchers and users can be brought together to advance seismic safety.

PAST, PRESENT, AND FUTURE FRONTIERS IN RESEARCH

Discussion in this session focused on NEHRP accomplishments and challenges from the perspective of the science, engineering and social science research communities.

Thomas Jordan, W. M. Keck Professor of Geological Sciences and director of the Southern California Earthquake Center, **University of Southern California**, noted that one of NEHRP's major achievements has been promoting the integration of earthquake science and earthquake engineering, resulting in a more coordinated system level science. He expressed hope that the transformation of the field into a system-level science will help close the implementation gap that exists in earthquake research and engineering practice. He maintained that researchers must look globally at earthquakes in order to better understand U.S. earthquakes. A better understanding is needed to determine how the earth is deforming to cause seismic events. Before and after studies of earthquake deformation may now be easier to conduct given advances in Satellite Assisted Research (SAR) imaging. Given the immense potential of these technologies, Jordan suggested that researchers may be closer to better prediction of strong ground motions. People need to appreciate that "risk" equals hazard multiplied by exposure multiplied by fragility. Therefore, accurate intensity maps are necessary along with deployment of more and better seismometers.

Jordan noted that in the United States, only 129 people have perished in earthquakes since 1980. However, earthquake fatalities worldwide over the same period exceed 200,000. Collecting and saving perishable earthquake data are necessary to better understanding the history of earthquake occurrences. Jordan noted that economic losses from earthquakes are rising rapidly, and this in part stems from immense growth in buildings and infrastructure.

Jordan reviewed some of what the science has yet to know about earthquakes. There is no physical theory to explain why earthquakes start and stop. There is lack of understanding of near-fault rupture and there is little known about the interaction between faults. However, advances in earthquake science have driven earthquake motion data collection and dissemination to near "real-time." While there are uncertainties about *when* large earthquakes will occur, the science has a good understanding of *where* earthquakes are likely to happen. Earthquake prediction has not yet reached a statistically reliable level, though researchers have made significant progress in explaining more about how faults work, in a direction where prediction is approaching statistically reliable levels on decadal terms or shorter.

Jordan stressed the importance of education and outreach. Researchers in seismology, geodesy, geology, geotechnical engineering, and rock mechanics need to promote integrated, multi-disciplinary studies of the earthquake phenomenon similar to "distributed collaboratories" used by climate science researchers. Jordan noted that substantially more investment in earthquake research is required and that the Advanced National Seismic System (ANSS) should be one of the nation's highest science priorities.

Thomas D. O'Rourke, Professor of Civil and Environmental Engineering, **Cornell University** and president of the **Earthquake Engineering Research Institute** discussed accomplishments and challenges in earthquake engineering research. He indicated that nationwide research programs of the type supported by NEHRP have helped the Federal Emergency Management Agency (FEMA) issue guidelines on new building and structures: FEMA 368/369, which set forth model seismic regulations for new buildings and FEMA 356/357, which focus on seismic retrofitting of existing buildings. O'Rourke pointed to HAZUS, the

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national loss estimation methodology, as another major accomplishment of NEHRP. He also mentioned progress in the SAC Steel Project, work on lifeline systems, underground construction technology advances, and geographic information technologies. However, he said more work is needed in spite of the progress that has been made over the years. This is reflected in the fact that estimated losses in the 1994 Northridge earthquake exceed $20 billion. (Kunreuther and Roth, 1998).

O'Rourke suggested that if the flat line funding NEHRP has experienced over the past 25 years continues into the future, it will be more important than ever for earth scientists, engineers, and social scientists involved in earthquake research to develop a coordinated technology transfer plan. O'Rourke noted that for 25 years the annual NEHRP budget represents less than one-twentieth of the annualized earthquake losses the nation experienced over the same period. O'Rourke stressed that consequently earthquake research funding is insufficient. People should consider earthquake research as a form of homeland security, particularly if the focus of this research is on application and products. He hoped that government leaders would see that earthquake research furthers homeland security efforts in the broadest sense, including providing knowledge and lessons for protecting buildings and infrastructure in the face of human-induced and natural hazards and contributing to risk communication. For example, he noted that following the September 11, 2001 terrorist attack, New York's telecommunications functioned well owing in part to its earthquake resistant design. (For an expanded summary of engineering accomplishments of NEHRP, see Abrams, 1999).

Daniel J. Alesch, Director of the Center for Organization Studies and a professor of political science and policy studies, **University of Wisconsin-Green Bay**, discussed the contributions of social science and planning research under NEHRP. The efforts supported through NEHRP have resulted in a greater understanding of the social and economic consequences of earthquakes. For example, much has been learned about the economic effects on regional and national economies, the economic effects on individual firms, the effects on the social fabric of communities, and the immediate and long-term effects on individuals and families. Alesch also noted that much has been learned about how individuals, organizations, and government respond to the earthquake threat and to earthquakes once they occur, including risk communication and about how to design and implement mitigation policy and programs.

The major challenge he sees facing NEHRP social scientists and other relevant researcher is the need to direct attention to communicating what has been learned to decision makers: legislators, owners, engineers, insurers, planners and public administrators. This requires becoming more problem-focused and multidisciplinary in addressing earthquake hazards and less constrained by disciplinary interests. Alesch emphasized that NEHRP as a whole has moved in this direction in some significant ways, and perhaps this is one of its greatest accomplishments. However, there is still much that needs to be done in this area before the collective goals of NEHRP can be achieved.

NEHRP CHALLENGES AND PRIORITIES

This session involved a discussion by the four NEHRP program principals focusing on the key challenges they see facing the program.

Craig Wingo directs **FEMA's Engineering Science and Technology Division**, which includes FEMA's National Earthquake Program. He pointed to many accomplishments under NEHRP, such as the development of risk assessment tools and resource documents for stakeholders, problem-focused research programs, and building code development activities, to name just a few. He said natural hazard knowledge could be leveraged to produce insight on reducing human-caused damage, including blast damage prevention and lifeline protection. He thinks that opportunities for such leveraging will increase since FEMA's NEHRP

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activity will be integrated into the new Department of Homeland Security (DHS). He recommends that researchers identify NEHRP work that contributes to specific DHS goals. There are great opportunities that NEHRP interests will find new partners within the DHS community.

As a future direction, Wingo proposed the formation of a new NEHRP subcommittee that would coordinate research activities across the four participating agencies. The chairpersonship would rotate among the agencies. One of the roles of the subcommittee would be to develop a more coordinated research agenda to maximize the existing and emerging resources of NIST, NSF, USGS and FEMA, such as NEES and ANSS. Wingo commented on the need to develop metrics to better measure program progress. He also noted that one of the major challenges facing NEHRP is developing effective incentives that motivate stakeholders to engage in sound seismic mitigation.

Wingo stressed that FEMA was committed to leading the completion of the NEHRP strategic plan. Such planning is critical since NEHRP budget for its activities has not kept up with inflation. Such planning should give increased attention to the need for interagency coordination and furthering and expediting the flow of research results into practice.

John Filson directs the **U.S. Geological Survey's Earthquake Hazards Program**. He pointed to several advances under NEHRP, including improved hazard monitoring and the development of paleoseismology. NEHRP is very important to USGS's work and as such the agency has a budget line item for NEHRP activities. In terms of future directions, Filson pointed out that more NEHRP research is needed in Alaska and the northeast; and that increased attention should be given to laying the scientific groundwork for earthquake prediction, which will require some initial strategic thinking. He also indicated that funding for ANSS was a major priority for USGS. In relation to this, the National Research Council has been asked to conduct a study on the benefits and costs of this system (ANSS).

Filson noted that NEHRP faces management and other major challenges. He said NEHRP requires strong leadership with a stronger program oversight from Congress. Congressional authorization and appropriation committee staffs must collaborate in addressing NEHRP. He also called for the creation of national and regional NEHRP platforms, venues, or opportunities that would allow stakeholders to get together to discuss their needs.

Priscilla Nelson, senior advisor in the **Directorate for Engineering at NSF**, saw a number of major challenges facing NEHRP. These include providing adequate funding for research to be carried out through NEES (www.nees.org and www.neesgrid.org), implementing the EarthScope Project, understanding the human dynamics of earthquake hazard reduction, and furthering performance-based engineering. Nelson said that one of the highest priorities for the program should be to develop an integrated cross-agency program that enables the earthquake community to make progress in research leading to hazards reduction, and that effectively implements the NEHRP strategic plan. NEHRP agencies also need to develop a strategy for making the case to the Office of Management and Budget that the program deserves strong support. Nelson pointed out other priority needs including increased multi-hazard activities (especially involving the social sciences), a greater incorporation of information technology into research and related activities, more international cooperation, and increased attention to earthquake hazard reduction workforce needs.

Shyam Sunder, chief of the Materials and Construction Research Division in **NIST's Building and Fire Research Laboratory**, noted that when NEHRP was created federal construction activities became part of the program's concern. Thus, NEHRP's Interagency Committee for Seismic Safety in Construction (ICSSC) was formed in 1978, which NIST has chaired since 1982. A major success for NEHRP has been the development of provisions for seismic safety for existing and new buildings, an effort in which NIST had a key role. Sunder noted that NIST was recently given new authority to investigate building failures, which is similar to responsibilities the National Transportation Safety Board has for investigating major transportation

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accidents. In this capacity, NIST operates as a neutral third party. NIST is researching the problem of progressive building collapse with the aim to promote retrofitting to prevent failures caused by multiple agents.

Sunder noted that one of the major challenges facing NEHRP is the promotion of improved lifeline seismic codes. He indicated that a private sector partnership is working to develop such codes with FEMA funding and the ICSSC is working to do the same for federal lifelines. Comparing damages from different disasters, he pointed out that while the United States annualized losses for wind damage is about $8 billion, and about $12 billion for fire damage, earthquake damages are about $4 billion, but a single earthquake event can exceed $100 billion in damages.

REFLECTIONS ON NEHRP

This final session involved reflections on the program by a senior stakeholder.

Robert A. Olson, president of **Robert Olson Associates**, reviewed the legislative history of NEHRP. He took special note of the role of NEHRP's congressional champions, Senator Alan Cranston, Congressman George E. Brown, and Congressman Charles A. Mosher, who formed an advocacy coalition that built political support for the program. Olson asserted that the 1964 Great Alaska Earthquake was a watershed event that helped propel national earthquake research. This interest was later reinforced by the losses caused by the 1971 San Fernando earthquake.

Reflecting on his own knowledge and drawing on comments made earlier during the workshop, Olson made several observations about NEHRP:

- In terms of real dollars, NEHRP's purchasing power has declined steadily to the level where essential program activities are being sacrificed because appropriations have not kept pace at least with inflation. Additionally, the community has identified other important needs that will further risk reduction if funding is provided.
- FEMA was assigned the leadership role in NEHRP in 1980. How the leadership role will be carried out now that FEMA is a part of the Department of Homeland Security is a concern for many in the earthquake community.
- In addition to the four NEHRP agencies, many federal agencies, such as Department of Defense, Department of Veterans Affairs, and General Services Administration, are directly involved in construction, which in many areas deals with earthquake risks. While NEHRP acknowledges these agencies, mechanisms for integrating these other risk reduction activities would increase seismic safety in the nation.
- A significant gap exists between the production and utilization of knowledge. There is a real need to reduce this gap through the program and quicken the pace of knowledge application.
- NEHRP agency representatives work in very complex and competitive environments. The agencies housing NEHRP activities have other missions and priorities. Thus any changes to NEHRP must be sensitive to these environments and address the organizational and financial capabilities needed to implement them successfully.
- Earthquake forecasting has been a useful tool in furthering community mitigation and preparedness actions. Perhaps earthquake prediction deserves to be revisited, especially given the advances that have been made in forecasting, accumulated knowledge in the earth sciences, and in relevant technology.

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APPENDIX A

February 20, 2003
Washington, DC

Final Agenda

8:15 AM	**Welcome and Introductions** *William H. Hooke,* NDR Chair, American Meteorological Society
8:50 AM	**Perspectives of NEHRP Agencies** Moderated discussion with key policy makers in the four NEHRP agencies. Issues to be addressed in this session include how the program fits into agencies' missions, their most significant program accomplishments and challenges faced during the past 25 years, and the greatest future challenge for the overall program. Moderator: *Richard Sylves*, University of Delaware
8:55 AM	*Anthony S. Lowe*, Administrator, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency
9:15 AM	*Charles G. Groat*, Director, U.S. Geological Survey
9:35 AM	*Peter Freeman*, Assistant Director, Computer and Information Sciences and Engineering Directorate, National Science Foundation
9:55 AM	*Arden L. Bement, Jr.,* Director, National Institute of Standards and Technology
10:15 AM	Questions and Discussion
10: 30 AM	BREAK
10:45 AM	**Putting NEHRP to Use** Moderated discussion on the accomplishments and challenges of implementing NEHRP from the perspective of private sector and government stakeholders. Moderator: *Susan Tubbesing*, Earthquake Engineering Research Institute
10:50 AM	*Ellis M. Stanley, Sr.*, City of Los Angeles

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11:10 AM	*Lloyd Cluff*, Pacific Gas and Electric
11:30 AM	*Chris D. Poland*, Degenkolb Engineers
11:50 AM	*Cliff Roblee*, California Department of Transportation
12:10 PM	Questions and Discussion
12:25 PM	LUNCH

1:35 PM **Past, Present, & Future Frontiers in Research**

Moderated discussion on research issues with perspectives from the science, engineering, and social science communities.

Moderator: David Applegate, American Geological Institute

1:40 PM	Earthquake Science *Tom Jordan,* University of Southern California
2:00 PM	Earthquake Engineering *Thomas D. O'Rourke*, Cornell University
2:20 PM	Social Science and Planning *Daniel J. Alesch, University of Wisconsin-Green Bay*
2:40 PM	Questions and Discussion
2:55 PM	BREAK

3:10 PM **NEHRP CHALLENGES AND PRIORITIES**

Moderated discussion with the program principals from the four NEHRP agencies focusing on such issues as the high priority challenges they see for their individual agencies and the program as a whole, including coordination, and the key messages they are taking away from the day.

Moderator: *Ross Corotis*, University of Colorado

Craig Wingo, FEMA

John Filson, USGS

Priscilla Nelson, NSF

Shyam Sunder, NIST

4:15 PM Questions and Discussion

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4:45 PM **Wrap-Up: Reflections on NEHRP**
Robert A Olson, Robert Olson Associates

5:15 PM Adjourn to Reception in Great Hall

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APPENDIX B

LIST OF REGISTRANTS

Dori Akerman, GRS Solutions, Inc.
Daniel Alesch, University of Wisconsin-Green Bay
Thomas L. Anderson, NSF
William Anderson, The National Academies
Dorothy Andrake, FEMA
David Applegate, American Geological Institute
Margaret Baker, American Geological Institute
Arden Bement, National Institute of Standards and Technology
B. Wayne Blanchard, FEMA/Emergency Management Institute
Suzanne Bolton, National Marine Fisheries Service
Andrew Bruzewicz, ERDC/CRREL
Jane Bullock, Bullock & Haddow, LLC
Michael Burke, American Institutes for Research
Dan Byers, House Science Committee
Mary Carrido, MLC & Associates, Inc.
Amar Chaker, American Society of Civil Engineers
Winston Chan, Multimax, Inc.
Lloyd Cluff, Pacific Gas and Electric
Rachel Cochrane, National Emergency Management Association
Peter Colohan, GRS Solutions, Inc.
Ross Corotis, University of Colorado, Boulder
William Cumming, Vacation Lane Group
Ellen de Guzman, The National Academies
Dana Decker, Federal Emergency Management Agency
Chris Doyle, Federal Emergency Management Agency
William Ellsworth, U.S. Geological Survey
Shou-shan Fan, Clarkson University
Antonio Fernandez, Earthquake Disaster Mitigation Research Center
John Filson, U.S. Geological Survey
Paul Flores, ABS Consulting
Peter Freeman, National Science Foundation
Peter Folger, AGU
Cyril Galvin, Coastal Engineer
Darci Glass-Royal, GRS Solutions, Inc.
Kathleen Gohn, U.S. Geological Survey
Paula Gori, U.S. Geological Survey
Fariborz Gorouhi, American Red Cross, Central Maryland Chapter
Charles Groat, U.S. Geological Survey
Michael Hales, NOAA's National Environmental Satellite, Data and Information Service
Robert Hamilton, The National Academies
Robert D. Hanson, University of Michigan
Jack Harrald, George Washington University
John Haynes, NASA Headquarters
Claret Heider, National Institute of Building Sciences
Mesumbe Henry Nzike, HESSA UB
Martin Hight, American Society of Civil Engineers
William Hooke, American Meteorological Society
Bakr Ibrahim, USNRC
Tom Jordan, University of Southern California
Mila Kennett, Federal Emergency Management Agency
Jeff Kimball, National Nuclear Security Administration
Fred Krimgold, World Institute for Disaster Risk Management
Edward Laatsch, Federal Emergency Management Agency
John LaBrecque, National Aeronautics and Space Administration
Patrick Leahy, U.S. Geological Survey
Clarese Lemberger, American Institutes for Research
Elizabeth Lemersal, FEMA/NEHRP
Chris Lewis, NOAA's National Environmental Satellite, Data and Information Service

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Anthony Lowe, Federal Emergency Management Agency
Don Lumpkins, City of Annapolis
Michael Mahoney, FEMA
Thomas McLane, Applied Technology Council
Charna Meth, American Geological Institute
Ugo Morelli
Vilas Mujumdar, National Science Foundation
Bernard Murphy, National Institute of Building Sciences
James Murphy, Michael Baker Jr., Inc.
Priscilla P. Nelson, National Science Foundation
Stuart Nishenko, Pacific Gas and Electric
Robert O'Connor, National Science Foundation
Robert Olson, Robert Olson Associates
Thomas O'Rourke, Cornell University
Chris Poland, Degenkolb Engineers
Jake Pauls, Jake Pauls Consulting Services
Max Ramery, GeoInformÃ¡tica
Tom Reed, Seismological Society of America
Cliff Roblee, California Department of Transportation
Claire Rubin, George Washington University
Eric Runnerstrom, University of California, Irvine
Charles Scawthorn, ABS Consulting
Barbara Schauer, National Institute of Building Sciences
Therese Schneck Frade, Civil Engineer
Philip Schneider, National Institute of Building Sciences
Hope Seligson, ABS Consulting
Anthony Socci, EPA Office of Atmospheric Programs
David Speidel, Queens College, CUNY
Ellis Stanley, City of Los Angeles
Jim Stanton, Maryland Institute for Emergency Medical Systems
Joseph Steller, National Institute of Building Sciences
Shyam Sunder, National Institute of Standards and Technology
Richard Sylves, University of Delaware
K. Thirumalai, U.S. DOT/RSPA
Susan Tubbesing, Earthquake Engineering Research Institute
Erik VanMarcke, Princeton University
Robert Volland, FEMA (Retired)
Anita Vollmer, FEMA
Maria Vorel, FIMA/FEMA/Homeland Security
Yumei Wang, Oregon Department of Geology and Mineral Industries
Larry Weber, National Science Foundation
Gene Whitney, Office of Science and Technology Policy
Maurita Williams, Capital Area Crisis Response Team
James Wilson, House Committee on Science
Craig Wingo, Federal Emergency Management Agency
Richard Wright
Arthur Zeizel, FEMA (Retired)

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APPENDIX C

SPEAKERS BIOS

Daniel J. Alesch was professor of public and environmental affairs at the University of Wisconsin-Green Bay before retiring and becoming director of the Center for Organizational Studies at the same university. Dr. Alesch has a B.S. and an M.S. from the University of Wisconsin, Madison and an M.A. and a Ph.D. from the University of California, Los Angeles.

David Applegate is director of government affairs at the American Geological Institute and Editor of Geotimes. Prior to arriving at AGI in 1995, he served as the American Geophysical Union's Congressional Science Fellow for the Senate Committee on Energy and Natural Resources and as a professional staff member for the minority.

Arden L. Bement, Jr. is director of the National Institute of Standards and Technology. Prior to his appointment as NIST director, Dr. Bement served as the David A. Ross Distinguished Professor of Nuclear Engineering and head of the School of Nuclear Engineering at Purdue University. Dr. Bement joined the Purdue faculty in 1992 after a 39-year career in industry, government, and academia. His positions included vice president of technical resources and of science and technology for TRW Inc.; director, Office of Materials Science, at DARPA; and professor of nuclear materials at MIT. He received an engineer of metallurgy degree from the Colorado School of Mines, a master's degree in metallurgical engineering from the University of Idaho, a doctorate degree in metallurgical engineering from the University of Michigan, and honorary doctorate degrees from Cleveland State University and Case Western Reserve University.

Lloyd S. Cluff is manager of the Geosciences Department at the Pacific Gas & Electric Company and is an expert on the identification of active seismic faults and their potential motions. Mr. Cluff has served the NRC in a number of capacities: as chair of the Committee on Practical Lessons from the Loma Prieta Earthquake, as a member of the U.S. National Committee for the Decade for Natural Disaster Reduction, and as a member of the Board on Earth Sciences. He also served as a member of numerous NRC committees, including the Committee on Assessing the Costs of Natural Disasters, the Subcommittee on Earthquake Research, and the Committee on Earthquake Engineering Research. Mr. Cluff is a member of the National Academy of Engineering.

Ross B. Corotis is Denver Business Challenge Professor of Engineering after serving as Dean of the College of Engineering and Applied Science at the University of Colorado at Boulder. He was on the faculty at Northwestern University for eleven years, and in 1981 established the Department of Civil Engineering at The Johns Hopkins University, which he chaired until becoming Associate Dean of Engineering in 1990. Dr. Corotis won the ASCE Walter L. Huber Civil Engineering Research Prize (1984), was named Civil Engineer of the Year (1986) and Outstanding Engineering Educator (1992) by the ASCE Maryland Section, and Engineer of the Year by the Baltimore Engineers' Week Council (1989). He currently serves as a steering committee member of the NRC's Natural Disasters Roundtable, as an Affiliate Member of the Multihazards Mitigation Council, and on NRC's Board of Assessment for NIST, where he is vice-chair of the Building and Fire Research Laboratory Panel. Dr. Corotis earned both his undergraduate and graduate degrees at the

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Massachusetts Institute of Technology, where he was an NSF Graduate Fellow. He is a member of the National Academy of Engineering.

John Filson is manager of the Earthquake Hazards Program of the U. S. Geological Survey. He has more than twenty years experience in managing scientific programs in earth sciences relating to reducing risks from earthquake hazards. In 1988 he led a team of geologists and engineers to Armenia to investigate the cause and effects of a devastating earthquake in that country. He has received the Distinguished Award of the U.S. Department of Interior and the Outstanding Public Service Award from the Federal Emergency Management Agency. Dr. Filson is a past president of the Seismological Society of America. He received a Doctor of Philosophy degree in Geophysics from the University of California, Berkeley.

Peter A. Freeman is assistant director for Computer and Information Science and Engineering at the National Science Foundation. From 1987 to 1989 he served as director of NSF's Computer and Computation Research Division within CISE, where he helped formulate the federal government's High-Performance Computing and Communications Initiative. Previously, Dr. Freeman was John P. Imlay, Jr. Dean of Computing at Georgia Institute of Technology. Since 1990, Dr. Freeman has served Georgia Tech as a professor and founding dean of the College of Computing. From 1992 to 1995, he also acted as the university's Chief Information Officer. Before coming Georgia Tech, he held previous faculty positions at George Mason University and the University of California at Irvine. He has served on numerous national panels and advisory committees, is a fellow of the Institute for Electrical and Electronics Engineers, the Association for Computing Machinery and the American Association for the Advancement of Science, and has been a member of the Board of Directors of the Computing Research Association since 1988. Dr. Freeman earned his Ph.D. in computer science from Carnegie-Mellon University.

Charles G. Groat is director of the U.S. Geological Survey. Dr. Groat is a distinguished professional in the earth science community with over 25 years of direct involvement in geological studies, energy and minerals resource assessment, ground-water occurrence and protection, geomorphic processes and landform evolution in desert areas, and coastal studies. Among his many professional affiliations, Dr. Groat is a member of the Geological Society of America, American Association for the Advancement of Science, American Geophysical Union, and the American Association of Petroleum Geologists. He has also served on over a dozen earth science boards and committees and has authored and contributed to numerous publications and articles on major issues involving earth resources and the environment. He received his bachelor's degree in geology from the University of Rochester, his master's degree from the University of Massachusetts, and his doctorate degree from the University of Texas at Austin.

William H. Hooke is a senior policy fellow and the director of the Atmospheric Policy Program at the American Meteorological Society. Prior to this, he worked for the National Oceanic and Atmospheric Administration (NOAA) and antecedent agencies for 33 years. After six years of research with NOAA he moved into a series of management positions including chief of the Wave Propagation Laboratory Atmospheric Studies Branch, director of NOAA's Environmental Science Group (now the Forecast Systems Lab), deputy chief scientist, acting chief scientist of NOAA. Between 1993 and 2000, he was also director of the U.S. Weather Research Program Office, and chair of the Interagency Committee on Environment and Natural Resources. Prior to NOAA, he was a faculty at the University of Colorado from 1969 to 1987. Dr. Hooke holds a B.S. in physics (with honors) from Swarthmore College, an S. M. and a Ph.D. from the University of Chicago.

Tom Jordan served as the head of MIT's Department of Earth, Atmospheric and Planetary Sciences for 10 years before becoming a W. M. Keck Professor of Geological Sciences and director of the Southern California Earthquake Center at the University of Southern California. His research interests are in the composition, dynamics, and evolution of the solid Earth, particularly the nature of plate-tectonic return flow, the formation of a thickened tectosphere beneath the ancient continental cratons, and the question of mantle

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stratification. He has developed a number of seismological techniques for elucidating structural features in the Earth's interior that bear on these and other geodynamic problems. He received the James B. Macelwane Medal of the American Geophysical Union in 1983 and the George P. Woollard Award of the Geological Society of America in 1998. He received his Ph.D. in geophysics and applied mathematics at the California Institute of Technology in 1972 and taught at Princeton University and the Scripps Institution of Oceanography before joining the MIT faculty as the Robert R. Shrock Professor of Earth and Planetary Sciences in 1984.

Anthony S. Lowe is administrator for the Federal Insurance and Mitigation Administration (FIMA), assuming the leadership of some of the nation's leading multi-hazard risk reduction programs. He oversees seven national hazard reduction programs, among them the National Flood Insurance Program, the National Earthquake Hazards Reduction Program, the National Dam Safety Program, and the National Hurricane program, just four of the seven national hazard reduction programs he oversees. Before assuming this post, Mr. Lowe served as the senior legislative counsel for the U.S. Senate Judiciary Subcommittee on Antitrust, Competition and Business Rights, and as staff on the Subcommittee on Terrorism, Technology and Government Information. Previously, he was the deputy prosecutor with the King County Prosecutor's Office in Seattle, Washington and a commissioner on the Planning Commission for the City of Redmond. Mr. Lowe holds a bachelor's degree in international political science from the University of Washington, a law degree from the University of Santa Clara, and a master's degree in theology from Virginia Union University.

Priscilla Nelson is senior advisor to the Directorate for Engineering at the National Science Foundation. She has been at NSF since 1994, and has served as Director of the Civil and Mechanical Systems Division, Senior Engineering Coordinator, Program Director for the Geotechnical Engineering program, and as Program Manager for the Network for Earthquake Engineering Simulation project that represents an $82 million federal investment in cyberinfrastructure and earthquake experimentation equipment to be completed between FY2000 and FY2004. Dr. Nelson was formerly Professor of Civil Engineering at The University of Texas at Austin. Dr. Nelson is Past-President of the Geo-Institute of the American Society of Civil Engineers, and a lifetime member and first President of the American Rock Mechanics Association. Among many other professional affiliations, she is a member of the American Underground-Construction Association, the Association of Engineering Geologists, the International Tunnelling Association, and the American Society for Engineering Education. She has served as a member of several National Research Council boards and committees. She received her master's degrees in geology from Indiana University and in structural engineering from the University of Oklahoma in structural engineering, and a doctorate degree in geotechnical engineering from Cornell University.

Robert A. Olson is present of Robert Olson Associates, Inc., where he consults on areas of earthquake hazards mitigation, emergency management, disaster operations, recovery assistance, and public policy development. Previously, he served as the first executive director of the California Seismic Safety Commission. He has chaired numerous committees including the Advisory Committee to the National Information Service of Earthquake Engineering, the Governor's Task Force on Earthquake Preparedness, and the Advisory Group on Disaster Preparedness to the California's Joint Legislative Committee on Seismic Safety. Mr. Olson also held a variety of research positions in various times at the Center for Environmental Design Research, the Institute of Governmental Studies, the Mid-America Earthquake Center, and the Pacific Earthquake Engineering Research Center. As part of the CUREE-Kajima research program, Mr. Olson has had affiliations with PEER, Stanford University, Caltech, and the University of Southern California. He received his bachelor's degree in political science from the University of California at Berkeley and his master's degree from the University of Oregon.

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Awards from American Society of Civil Engineers (ASCE), the Hogentogler Award from American Society for Testing and Materials, and the Trevithick Prize from the British Institution of Civil Engineers. He is President of the Earthquake Engineering Research Institute (EERI), with term of office from 2003-2005. He is also a member of the US National Science Foundation Engineering Advisory Committee and the Consortium of Universities for Research in Earthquake Engineering Board of Directors. He is a member of the Executive Committees of the Multidisciplinary Center for Earthquake Engineering Research and the Institute for Civil Infrastructure Systems. He has served as Chair of the Executive Committee of the ASCE Technical Council on Lifeline Earthquake Engineering. He has authored or co-authored over 280 publications on geotechnical and earthquake engineering. He received the EERI Outstanding Paper Award. He has served on numerous earthquake reconnaissance missions, and has chaired or been a member of the consulting boards of projects for highway, rapid transit, water supply, and energy distribution systems. His research interests cover geotechnical engineering, earthquake engineering, lifeline systems, underground construction technologies, and geographic information technologies and database management. He is a member of the National Academy of Engineering and an elected Fellow of American Association for the Advancement of Science.

Chris D. Poland is president and chief operating officer of Degenkolb Engineers. Before becoming president of the Earthquake Engineering Research Institute, Mr. Poland served as director/secretary-treasurer for six years. His interests are in new design work, seismic analysis, structural evaluation, strengthening of existing buildings, failure analysis, and historic preservation. Mr. Poland has also participated in numerous research projects, which contributed among others, to the development of federal standards for seismic evaluations and mitigation (a NIST study(and numerous guidelines related to earthquake hazard reduction activities such as the National Earthquake Hazard Reduction Series Program Handbooks for seismic evaluation of existing buildings (FEMA 178, etc.). He also was chairman of the Vision 2000 Codes Committee of the Structural Engineers Association of California, which produced *Performance Based Seismic Engineering of Buildings: Interim Recommendations* (1995). He received his bachelor's degree in mathematics (summa cum laude) from the University of Redlands and master's degree in structural engineering from Stanford University.

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Susan K. Tubbesing is the executive director of the Earthquake Engineering Research Institute (EERI) in Oakland, California, a national, nonprofit, technical society of engineers, geoscientists, architects, planners, public officials, and social scientists. Prior to her work at EERI, Ms. Tubbesing was manager of the Natural Hazards Research and Applications Information Center at the University of Colorado, Boulder. She has published widley on natural disasters, and specifically earthquake policy issues. She holds a bachelor's degree in anthropology and a masters degree in education from Washington University.

Craig S. Wingo is the director of the Engineering Science and Technology Division, which houses both the National Earthquake and Dam Safety Programs, the building sciences, code development and risk assessment functions within the Administration. Mr. Wingo served as the Deputy Associate Director of the Mitigation Directorate from May 1996 to February 1999. In that capacity, he oversaw special projects covering a broad spectrum of FEMA's mitigation programs, including the post-disaster Hazard Mitigation Grant Programs for the rehabilitation and retrofit of buildings and infrastructure, FEMA's buyout and relocation programs, and the Agency's extensive mapping and floodplain management efforts. Prior to this appointment, he served as the Director of the Infrastructure Support Division in FEMA's Response and Recovery Directorate. Prior to that position, he served as the Assistant Associate Director of the Office of Technological Hazards. During this period, he served as FEMA's representative on the National Response Team and was also responsible for the achievement of FEMA's expanded interagency responsibilities in the Hazardous Materials Transportation Act.

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