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THE REAUTHORIZATION OF THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM: R&D FOR DISASTER RESILIENT COMMUNITIES

HEARING

BEFORE THE

SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

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THE REAUTHORIZATION OF THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM: R&D FOR DISASTER RESILIENT COMMUNITIES

THURSDAY, JUNE 11, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:20 a.m., in Room 2318 of the Rayburn House Office Building, Hon. David Wu [Chair of the Subcommittee] presiding.

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Subcommittee on Technology and Innovation's

Hearing on

THE REAUTHORIZATION OF THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM: R&D FOR DISASTER RESILIENT COMMUNITIES

Thursday, June 11, 2009
10:00a.m. – 12:00p.m.
2318 Rayburn House Office Building

Witness List

Dr. John R. Hayes
Director, National Earthquake Hazards Reduction Program (NEHRP), National Institute of Standards and Technology (NIST)

Dr. Michael Lindell
Professor of Landscape Architecture & Urban Planning, Texas A&M University

Professor Thomas O'Rourke
Thomas R. Briggs Professor of Engineering, School of Civil & Environmental Engineering, Cornell University

Dr. James Robert Harris, P.E.
President, J. R. Harris & Company

Mr. Kenneth Murphy
Immediate Past President, National Emergency Management Association (NEMA); Director, Oregon Office of Emergency Management

HEARING CHARTER

SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

The Reauthorization of the National Earthquake Hazards Reduction Program: R&D for Resilient Communities

THURSDAY, JUNE 11, 2009
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

I. Purpose

On Thursday 11 June, the Subcommittee on Technology and Innovation of the Committee on Science and Technology will hold a hearing to review the National Earthquake Hazards Reduction Program (NEHRP) in preparation for reauthorization. Funding currently expires at the end of fiscal year 2009.

II. Witnesses

Dr. John Hayes is the Director of the National Earthquake Hazards Reduction Program (NEHRP) at the National Institute of Standards and Technology (NIST).

Dr. Michael Lindell is the Director of the Hazards Reduction and Recovery Center, and a Professor of Landscape Architecture & Urban Planning at Texas A&M University.

Professor Thomas O'Rourke is the Thomas R. Briggs Professor of Engineering at the School of Civil & Environmental Engineering at Cornell University.

Dr. James Robert Harris, P.E., is the President of J.R. Harris & Company.

Mr. Kenneth Murphy is the Director of the Oregon Office of Emergency Management and the Immediate Past President of the National Emergency Management Association (NEMA).

III. Hearing Issues

- The last NEHRP reauthorization named NIST as the lead agency. How well is NEHRP performing with NIST as the head agency? Where are there opportunities to improve coordination among the agencies? What are the priorities for NEHRP moving forward?
- Understanding the human element of hazard mitigation is crucial to the implementation of mitigation measures. What is the role of social science in creating disaster resilient communities? How has social science research and knowledge been integrated into NEHRP activities? Where are there opportunities for improvement?
- Hazard mitigation tools and products must meet the needs of State and local officials who must prepare their communities for disasters and help them respond. How well do NEHRP activities meet State and local needs? How can these needs be better aligned?
- The damage from an earthquake could be catastrophic. However, other natural hazards, such as hurricanes and wildfires, also pose significant dangers. The Federal Government has focused comparatively less R&D on those hazards. How should the Federal Government address R&D for other natural hazards and what opportunities exist to coordinate hazards R&D across the Federal Government?

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IV. Background

Natural Hazard Exposure in the U.S.

Americans' exposure to natural hazards is significant. If populations continue to grow in areas prone to earthquakes, severe weather, or wildfires, this exposure will only increase. Between 1990 and 2001, the Federal Emergency Management Agency (FEMA) paid out over $39 billion in disaster relief. That amount is nearly five times greater than the $7 billion paid out between 1978 and 1989. Although more activities became eligible for funding during the later period, the number reflects the sharp increase in natural disaster losses experienced by Americans. And, as shown below, while the number of casualties from natural hazards in the U.S. is comparatively lower than in many other countries, the potential for loss of life and bodily injury is still very high.[1]

- *Earthquakes.* Eighteen U.S. states are in highly seismically active areas, though nearly all states have some seismic risk. About 75 million Americans live in these seismically active zones, many in growing urban areas. Though infrequent, earthquakes are unique among natural hazards in that they strike without warning. In addition, earthquakes in the U.S. and worldwide illustrate that the effects can be catastrophic. The 6.9 magnitude Kobe, Japan earthquake in 1995 killed more than 5,000 people and caused an estimated $200 billion in damages. The 1994 Northridge, California earthquake (magnitude 6.7) resulted in over $40 billion in damage. The fact that it took only 59 lives, in comparison to 5,000, is widely attributed to building code advancements and other mitigation measures. However, in a scenario run by the USGS as part of the Great Southern California Shake Out, a 7.2 Southern San Andreas Fault earthquake would result in an estimated 1,800 fatalities in the San Bernadino and a predicted $200 billion in direct losses. Earthquakes are not a hazard confined to the Western U.S. A report prepared by the Central U.S. Earthquake Consortium showed that an earthquake on the New Madrid fault could cause as many as 85,000 fatalities and injuries and over $100 billion in direct economic losses in the States of Tennessee and Missouri.
- *Tsunamis.* U.S. coastal regions are vulnerable to tsunamis generated from submarine earthquakes. The world saw the catastrophic impact of tsunamis in 2004 when an earthquake off the coast of Sumatra, Indonesia unleashed a tsunami that killed approximately 170,000 people and generated $186 million in damages. A high magnitude earthquake in the Cascadia subduction zone off the Pacific Northwest would be devastating to the coastal communities.
- *Severe Weather.* High winds in hurricanes, tornadoes, thunderstorms, and other weather phenomena cause significant damage to buildings and infrastructure. Annually, such weather is also responsible for an average of 124 American fatalities and over 1,600 injuries each year.[2] Total direct property losses in the U.S. from 1996 to 2006 are over $160 billion (in 2006 dollars).[3] Costs associated with wind-related natural disasters have doubled or tripled each decade over the past 35 years.
- *Wildfires.* Construction of homes and communities at the edge of wildlands is a growing practice. In the Western U.S. alone, almost 38 percent of new construction is in the wildland-urban interface (WUI). The most recent figures are unavailable, but from 1985 to 1994, WUI fires destroyed more than 9,000 homes. The Oakland Hill fire in 1991 that took 3,000 structures caused $1.2 billion in property losses.[4]

The National Earthquake Hazards Reduction Program

Congress created NEHRP in 1977 with passage of the *Earthquake Hazards Reduction Act* (P.L. 95–124). Created largely in response to the 1964 Alaska Earthquake and the San Fernando Earthquake of 1971, the original program called on 10 federal agencies to coordinate activities to implement an earthquake prediction system, develop design and construction methods for earthquake resilience, identify

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[1] Loss of live and damage estimates from natural hazards vary widely. The figures here are cited from a 2003 RAND study, *Assessing Federal Research and Development for Hazard Loss Reduction.*

[2] Average calculated from National Weather Service data from 1996 to 2006, exclusive of the more than 1,000 hurricane deaths in 2005.

[3] *http://www.nws.noaa.gov/om/hazstats.shtml*

[4] U.S. Fire Administration, *Topical Fire Research Series*, Vol. 2, Issue 16, March 2002.

seismic hazards and make model code and land-use recommendations, increase the understanding of earthquake risks, and educate the public about earthquakes. The 1980 reauthorization of the program designated FEMA as the lead agency.

The 2004 reauthorization (P.L. 108–360) changed the lead agency from FEMA to NIST. This change reflected concern that FEMA, newly in the Department of Homeland Security (DHS), was no longer as focused on natural hazards mitigation. In addition, the legislation established an Interagency Coordinating Council (ICC) composed of the directors of NIST, FEMA, the National Science Foundation (NSF), the United States Geological Survey (USGS), the Office of Science and Technology Policy (OSTP), and the Office of Management and Budget (OMB). To ensure the coordination processes, the ICC is required to meet at least three times annually and to develop a strategic plan and coordinated interagency budget.

The four designated NEHRP agencies support the development of earthquake hazard reduction measures, promote the adoption of these measures, and improve understanding of earthquake phenomena and their effects on structures, infrastructure, and communities, as explained below:

- NIST: In addition to serving as the lead agency, NIST supports the development, evaluations, and testing of earthquake resistant design and construction practices for implementation in building codes and practices.
- FEMA: FEMA develops earthquake risk modeling tools and supports the development of disaster-resistant building codes and standards.
- NSF: NSF supports basic research and research facilities in Earth sciences, engineering, and social sciences relevant to understanding the causes and impacts of earthquakes, and with a goal of developing practical tools to reduce their effects. NSF supported earthquake engineering facilities include the George E. Brown Network for Earthquake Engineering Simulation (NEES).
- USGS: The USGS supports research to better understand earthquake causes and effects, produces national and regional seismic hazards maps, monitors and rapidly reports on earthquakes and their shaking intensities in the U.S. and abroad, and works to raise public earthquake hazard awareness. The USGS maintains the Advanced National Seismic System (ANSS) and the Global Seismic Network (GSN). Currently, ANSS is approximately 15 percent deployed (820 out of 7,100 planned stations). With money from the *American Recovery and Reinvestment Act,* USGS plans to modernize 800 analogue stations, brining the network up to 1,620 sensors.

Over the past 30 years, NEHRP activities have been instrumental in developing and advancing earthquake knowledge, seismic building codes, and raising the awareness of officials and the general public about earthquake hazards. These contributions include:

- An improved understanding of earthquakes and their effects, such as seismic wave propagation, through research and seismic monitoring. Among other applications, this knowledge has been used in the development of seismic hazard assessments, building codes, and in tools for modeling the effects of an earthquake disaster.
- Improved seismic building codes through research, mapping, and seismic monitoring. The National Seismic Hazards Maps and other research produced the NEHRP *Recommended Provisions for Seismic Regulations for New Buildings and Other Structures,* which is the basis for the seismic elements of model building codes. NEHRP has also supported work to improve the safety of existing structures, supporting work that lead to the development of consensus-based standards to evaluate and rehabilitating existing buildings for seismic safety.
- NEHRP has supported the development of partnerships with State and local governments, professional groups, and multi-State earthquake consortia to raise public awareness and support mitigation efforts. These groups, like the Central U.S. Earthquake Consortium, receive funds from NEHRP and State, local, and private partners.
- USGS products provide real-time earthquake notification, showing the magnitude and location of an earthquake. These products include *ShakeMaps* and PAGER—Prompt Assessment of Global Earthquakes for Response. These products provide near real-time information on the location, distribution, and severity of ground-shaking. Officials can use this information in mounting a more effective emergency response and recovery.

Tables 1 and 2 below show the authorized and actual levels of funding for NEHRP over the last reauthorization period.

Table 1. Funding authorized for NEHRP, in millions (including funding for NEES and ANSS).

Agency	FY 2005	FY 2006	FY2007	FY 2008	FY 2009
FEMA	21.0	21.63	22.3	23.0	23.64
NIST	10.0	11.0	12.1	13.3	814.6
NSF	58.0	59.5	61.2	62.9	64.7
USGS	77.0	84.4	85.9	87.4	88.9
Total	166.0	176.5	181.5	186.6	191.8

Table 2. Actual funding for NERHP, in millions (including funding for NEES and ANSS).

Agency	FY2005	FY2006	FY 2007	FY2008	FY2009 (Requested)
FEMA	14.7	9.5	7.2	6.1	8.6
NIST	0.9	0.9	1.7	1.7	6.4
NSF	53.1	53.8	54.2	55.6	56.4
USGS	58.4	54.5	55.4	58.1	53.1
Total	127.1	118.7	160.55	121.5	124.5

Network for Earthquake Engineering Simulation

From 1999 to 2004, NSF invested $83 million to build earthquake engineering research facilities at 15 universities, linked by information technology (IT) infrastructure that integrates the facilities and makes them accessible from remote locations. In addition, the last reauthorization authorized an average of $20 million per fiscal year exclusively for operation and maintenance (nearly all of which was received). NEES offers considerable potential to advance earthquake engineering knowledge. However, as reported in a 2007 NSF Site Visit Report, NEES had weak leadership and insufficient direction and planning for its Education, Outreach, and Training activities. Most critical, the Site Visit Committee noted the failure of the NEES IT subcontractor to produce products that fit the needs of stakeholders.

Strategic Plan

In the required Strategic Plan for 2009 to 2013, the NEHRP agencies laid out nine strategic priorities to accomplish the goals of understanding earthquakes and their impacts, developing cost-effective measures to reduce these impacts, and improve earthquake resiliency nationwide. These nine priorities are:

- Fully implement the ANSS
- Improve techniques for evaluating and rehabilitating existing buildings
- Further develop performance-based seismic design
- Increase consideration of socioeconomic uses related to hazard mitigation implementation
- Develop a national post-earthquake information management system
- Develop advanced earthquake risk mitigation technologies and practices
- Develop guidelines for earthquake-resilient lifeline components and systems
- Develop and conduct earthquake scenarios for effective earthquake risk reduction and response and recover planning
- Facilitate improved earthquake mitigation at State and local levels.

The National Windstorm Impact Reduction Program

The last reauthorization of NEHRP also contained the National Windstorm Impact Reduction Program (NWIRP) in a separate title. The legislation directs the National Oceanic and Atmospheric Administration (NOAA), NIST, NSF, and FEMA to support activities to improve the understanding of windstorms and their impacts, and to develop and encourage the implementation of cost-effective mitigation measures to reduce these impacts. The statute charges an interagency working group (IWG)—chaired on a rotating basis by FEMA, NSF, NOAA, and NIST—to coordinate the R&D priorities, portfolio, and budget. The program was authorized through FY 2008 (Table 3).

Table 3. Funding Authorized for NWIRP

Agency	FY 2006	FY 2007	FY 2008
FEMA	8.7	9.4	9.4
NSF	8.7	9.4	9.4
NIST	3.0	4.0	4.0
NOAA	2.1	2.2	2.2
Total	22.5	25.0	25.0

The NWIRP implementation plan submitted in April 2006 assessed programs relevant to the goals of NWIRP across eight federal agencies and identified important areas of research that were not covered by current activities. The knowledge gaps covered the three broad categories of research authorized in the Act: understanding windstorms; assessing the impacts of windstorms; and mitigating the effects of windstorms. The implementation plan also recommends that an IWG within the National Science and Technology Council's (NSTC) Committee on Environment, Natural Resources Subcommittee on Disaster Reduction oversee the research portfolio outlined above, with representatives from NSF, NIST, NOAA, and FEMA, as well as the National Aeronautics and Space Agency (NASA), the Federal Highways Administration (FHWA), and the Army Corps of Engineers. The IWG would be responsible for facilitating communication between the agencies on the best means of allocating agency resources to meet NWIRP goals and for coordinating this federal research portfolio.

The Subcommittee on Technology and Innovation held a hearing on NWIRP in July, 2008.[5] The witnesses testified that the funding levels devoted by the agencies to wind hazard mitigation R&D were not adequate to meet the growing need (approximately $7.5 million since FY 2004) and that no coordinated program existed. It was also noted that in some cases there were research findings that had yet to be translated into practical applications due to a lack of funding. They identified a number of priorities for wind hazard R&D, including:

- Developing a better understanding of wind phenomena to better estimate maximum hurricane wind speeds, velocity profiles, and turbulence characteristics needed for building design
- Better understanding of wind-structure interactions
- Performance-based design for windstorm hazards

Fire R&D at NIST

In the *Federal Fire and Prevention Control Act of 1974* (P.L. 93–498) as amended, NIST has authority for "performance and supporting research on all aspects of fire with the aim of providing scientific and technical knowledge applicable to the prevention and control of fires." As NIST testified for the Technology and Innovation Subcommittee in October of 2007,[6] structure fires kill over 3000 people in the U.S. each year. They also cause approximately $10 billion in damages each year according to the National Fire Protection Association. Through its Buildings and Fire Research Lab (BFRL), NIST supports research to reduce fire hazards within residences and commercial buildings, and supports R&D to improve fire codes, standards, and provisions. In its FY 2009 request, NIST also included $4 million for a Disaster Resilient Structures and Communities Initiative, which included R&D to mitigate fire damage for structures in the WUI. NIST reports funding about $1 million each in FY 2008 and FY 2009 on WUI related research.

[5] *http://science.house.gov/publications/hearings_markups_details.aspx?NewsID=2271*
[6] *http://science.house.gov/publications/hearings_markups_details.aspx?NewsID=1961*

Social Science

Because natural hazards affect people and communities, social science is an integral part of understanding and mitigating society's risk. A 2006 National Research Council (NRC) report[7] identified the contributions of NEHRP to this area, noting that social science related knowledge on exposure and vulnerability to hazards expanded greatly under NEHRP, enabling the development of loss estimation tools and related decision support tools. However, the report noted that efforts are needed to compare catastrophic events and to examine societal responses in relation to variables such as warning time, magnitude, scope, and duration of impact. More social science research is also needed on understanding longer-term disaster recovery. The report also highlighted the need for the management of social science data.

[7] Facing Hazards and Disasters: Understanding Human Dimensions, NRC 2006.

Chair WU. This hearing will come to order.

I want to welcome everyone to—oh, my gosh, how rude of me. I am so focused on what is immediately in front of me, which is the hazard of this line of work. Please, the witnesses may be seated. Terrific. Welcome everyone.

This is the third in a series of hearings the Subcommittee has held on programs that address threats to our communities, including wind, fire, and earthquakes.

We will hear today that the National Earthquake Hazards Reduction Program, or NEHRP, has made many significant strides in enhancing earthquake safety and is a valuable program. However, the Subcommittee has also found that federal agencies currently have a stovepipe approach to hazards mitigation research activities. Separate and distinct programs exist for earthquake, tsunami, fire, and wind threats, despite areas of commonality such as prediction research, emergency preparedness needs, and the potential for mitigation via enhanced construction codes. Even more importantly, the key to successful mitigation of any and all potential hazards is a coordinated and effective public education program.

The statistics tell the story. In the United States, wind and fire cause approximately $28 billion worth of damage and kill an average of 4,300 Americans each year.

Earthquakes, while more episodic, can be devastating in their impact. The 1994 Northridge Earthquake took 59 lives and resulted in over $40 billion in damage. I think we can all agree that we can, and must, do a better job of hazards mitigation in order to protect our communities as much as possible from the devastation of natural disasters.

One question we can raise is whether the current structure of federal hazards research is optimal and how we could improve it. The 2004 changes to NEHRP have been widely supported. NIST [National Institute of Standards and Technology], via the leadership of Dr. John Hayes, has received high marks for its coordination of the program. We must note that research for other hazards has yet to produce the similar advances. This lag may exist because wind, fire, and tsunami mitigation do not have the same federal R&D [research and development] structure that has produced our many advances on the seismic front.

Today we will hear from experts on needs for the National Earthquake Hazards Reduction Program. I hope to also learn if a program structured like NEHRP might also improve wind, fire, and tsunami research programs.

It is worth exploring whether a coordinated, comprehensive, and fully funded hazards mitigation program could be a more effective approach than the current stovepipe structure, where different hazards communities fight for their own funding priorities and lessons learned are less likely to be shared between those researching different threats.

In the end, the goal of research on all hazards, earthquakes, wind, fire, and tsunamis is the same, to save lives, protect our communities and preserve property.

I want to thank our witnesses for appearing before us today, and now I would like to turn to the gentleman from Nebraska, Mr. Smith, for his opening statement.

[The prepared statement of Chair Wu follows:]

PREPARED STATEMENT OF CHAIR DAVID WU

I want to welcome everyone to today's hearing. This is the third in a series of hearings the Subcommittee has held on programs that address threats to our communities, including wind, fire, and earthquake disasters.

I think we will hear today that the National Earthquake Hazards Reduction Program—or NEHRP—has made many significant strides in enhancing earthquake safety and is a valuable federal program. However, the Subcommittee has also found that federal agencies currently have a stovepipe approach to hazards mitigation research activities. Separate and distinct programs exist for earthquake, tsunami, fire, and wind threats, despite areas of commonality such as prediction research, emergency preparedness needs, and the potential for mitigation via enhanced construction codes. Even more importantly, the key to successful mitigation of any and all potential hazards is a coordinated and effective public education program.

The statistics tell the story—in the United States, wind and fire cause approximately $28 billion worth of damages and kill an average of 4,350 Americans each year. Earthquakes, while periodic, also can be devastating in their impact. For example, the 1994 Northridge Earthquake took 59 lives and resulted in over $40 billion in damages. I think we can all agree that we can and must do a better job of hazards mitigation in order to protect our communities as much as possible from the devastation these disasters can cause.

One question we can raise is whether the current structure of federal hazards research is optimal and how we could improve it. The 2004 changes to National Earthquake Hazard Reduction Program have been widely supported. NIST, via the leadership of Dr. John Hayes, has received high marks for its coordination of the program. As we discuss the successes in earthquake mitigation and priorities moving forward, we must note that research for other hazards has yet to produce the same advances. This lag may exist because wind, fire, and tsunami mitigation do not have the same federal R&D structure that has produced our many advances on the seismic front.

Today we will hear from experts on needs for the National Earthquake Hazards Reduction Program. But, I hope to also learn if a program structured like NEHRP might also improve wind, fire, and tsunami research programs.

It is worth exploring whether a coordinated, comprehensive, and fully funded hazards mitigation program could be a more effective approach than the current stovepipe structure, where different hazards communities fight for their own funding priorities and lessons learned are less likely to be shared between those researching various threats.

In the end, the goal of research on all hazards—earthquakes, wind, fire, and tsunamis—is the same—to protect our communities and save lives.

Mr. SMITH. Thank you, Mr. Chair, and thank you for holding this hearing today to consider reauthorization of the National Earthquake Hazards Reduction Program, otherwise known as NEHRP.

All natural hazards, be they floods, wildfires, tornadoes, hurricanes, earthquakes, and in my district close to home yesterday, hail present a common mitigation challenge in that while inevitable and potentially catastrophic events, they are infrequent and certainly unpredictable. These characteristics are particularly pronounced for damaging earthquakes which are rare and impossible to predict on any practical time scale. This infrequency has the tendency to drive stakeholders at all levels to become complacent and allow attention to earthquake hazards reduction efforts to fade in favor of more pressing and urgent matters. Nonetheless, we know the damage from a major U.S. earthquake could cost tens of billions of dollars or more and that scientists are forecasting a 99 percent chance that California will experience a major earthquake 6.7 magnitude or greater within the next 30 years. These figures serve as a stark reminder that we should remain committed to reducing our vulnerability to earthquakes as an ounce of mitigation

could be worth a pound of cure in the form of reducing loss of life and property when the so-called big one hits.

To this end I want to commend NIST and the participating NEHRP agencies for their efforts to strengthen the coordination and visibility of NEHRP in recent years. I thank Chair Wu for initiating this review process this year in order to keep the program authorized without interruption.

Our witnesses today represent a diversity of backgrounds and expertise reflective of the breadth of the NEHRP program and hazard mitigation in general, and I look forward to hearing the recommendations on how to best further improve the program and leverage its resources most effectively. Thank you.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF REPRESENTATIVE ADRIAN SMITH

Mr. Chairman, thank you for holding this hearing today to consider reauthorization of the National Earthquake Hazards Reduction Program (NEHRP).

All natural hazards—be they floods, wildfires, tornadoes, hurricanes, or earthquakes—present a common mitigation challenge in that, while inevitable and potentially catastrophic events, they are infrequent and relatively unpredictable. These characteristics are particularly pronounced for damaging earthquakes, which are rare, and impossible to predict on any practical time scale.

This infrequency has a tendency to drive stakeholders at all levels to become complacent and allow attention to earthquake hazards reduction efforts fade in favor of more pressing and urgent matters. Nonetheless, we know that damage from a major U.S. earthquake could cost tens of billions of dollars or more, and that scientists are forecasting a 99 percent chance that California will experience a major earthquake (6.7 magnitude or greater) within the next 30 years.

These figures serve as a stark reminder that we should remain committed to reducing our vulnerability to earthquakes, as an ounce of mitigation could be worth a pound of cure in the form of reducing loss of life and property when "the big one" hits.

To this end, I want to commend NIST and the participating NEHRP agencies for their efforts to strengthen the coordination and visibility of NEHRP in recent years, and I thank Chairman Wu for initiating this review process this year in order to keep the program authorized without interruption.

Our witnesses today represent a diversity of backgrounds and expertise reflective of the breadth of the NEHRP program and hazard mitigation in general, and I look forward to hearing their recommendations on how best to further improve the program and leverage its resources most effectively.

Thank you, Mr. Chairman.

Chair WU. Thank you, Mr. Smith. If there are other Members who wish to submit opening statements, your statements will be added to the record at this point.

[The prepared statement of Mr. Mitchell follows:]

PREPARED STATEMENT OF REPRESENTATIVE HARRY E. MITCHELL

Thank you, Mr. Chairman.

Today we will review the National Earthquake Hazards Reduction Program (NEHRP) and examine the performance of this program under NIST.

While earthquakes cause significant and catastrophic damage, other natural hazards, including wildfires, also pose serious dangers. However, these other natural hazards have received comparatively less R&D.

Today we will also discuss the potential to increase R&D for other natural hazards, such as wildfires, as well as what opportunities may exist to coordinate hazards R&D on a federal level.

In Arizona, fires on the wildland-urban interface pose a significant threat. As the construction of homes and communities at the edge of wildlands increases, we are also seeing an increase in wildfires that ignite close by homes and other community buildings.

I look forward to hearing more from our witnesses on how we can improve our R&D efforts.

I yield back.

Chair WU. Now it is my pleasure to introduce our witnesses. Dr. John Hayes is the Director of the National Earthquake Hazards Reduction Program, or NEHRP, at the National Institute of Standards and Technology, or NIST. Mr. Kenneth Murphy is the Immediate Past President of the National Emergency Management Association [NEMA] and the Director of the Oregon Office of Emergency Management. Professor Thomas O'Rourke is the Thomas R. Briggs Professor of Engineering at the School of Civil and Environmental Engineering at Cornell University. Dr. Michael Lindell is the Professor of Landscape Architecture and Urban Planning at Texas A&M University. And finally, Dr. James Robert Harris is the President of J.R. Harris & Company.

Dr. Hayes, if you would please begin. Your written statement will be fully entered into the record and could you please try to summarize your written statement into a five-minute oral statement. Dr. Hayes.

STATEMENT OF DR. JOHN R. HAYES, JR., DIRECTOR, NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM (NEHRP), NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST), U.S. DEPARTMENT OF COMMERCE

Dr. HAYES. Thank you, Chair Wu, Ranking Member Smith, and Members of the Subcommittee. Thank you for inviting me to testify on the reauthorization of the National Earthquake Hazards Reduction Program, or NEHRP, as you have said.

My testimony focuses on the four-agency NEHRP partnership: FEMA [Federal Emergency Management Agency], NIST, NSF [National Science Foundation], and USGS [United States Geological Survey]. This partnership works closely with the earthquake community including other federal agencies, State and local governments, professional organizations, model building code and standards organizations, and earthquake professionals in the private sector and academia.

Seismologists strongly agree that damaging earthquakes in the U.S. are inevitable and unpredictable. This April's 6.3 magnitude earthquake in Italy that cost 300 lives and the May 2008 magnitude 7.9 earthquake in China that cost tens of thousands of lives are sobering reminders that unexpected tragedies can occur.

The establishment of NEHRP was predicated on the belief that earthquakes are inevitable but earthquake disasters are not. As you know, the 2004 reauthorization of NEHRP directed several changes in the program's organization. NIST was given a new role as the NEHRP lead agency. To fulfill that role, NIST established the NEHRP Secretariat that supports the activities of the NEHRP Interagency Coordinating Committee and the Advisory Committee on Earthquakes Hazards Reduction which were also created by the last reauthorization. By involving the leaders of the program agencies and of OMB [Office of Management and Budget] and OSTP [Office of Science and Technology Policy], the Interagency Coordinating Committee has significantly improved program visibility, decision-making, and coordination. The Advisory Committee provides nationally renowned earthquake professional expertise to as-

sist the Interagency Coordinating Committee members in establishing program direction.

In 2008, the NEHRP agencies released a new strategic plan that sets a new program vision: "A nation that is earthquake resilient in public safety, economic strength, and national security." The plan sets three broad program goals, adds strategic priorities for the future, and describes a number of guiding philosophical principles. One key principle is that NEHRP will identify valuable areas of synergy with activities associated with other hazards.

Recent NEHRP annual reports provide substantial information regarding agency activities, and I shall cover a few highlights.

The USGS is the applied Earth science component of NEHRP and has made great strides in its delivery of comprehensive earthquake information from monitoring systems both in the United States and worldwide. In the United States, monitoring relies upon the Advanced National Seismic System. The National Earthquake Information Center assimilates monitoring the data on a 24/7 basis and issues rapid reports of earthquakes and their impacts.

In 2008, USGS released new national seismic hazard maps that incorporate the most recent field observation and research results and are being used to develop design maps for national model building codes.

NSF is the basic research arm for NEHRP supporting research that addresses Earth science, geotechnical and structural engineering, lifeline engineering, and the social sciences.

NSF has established the George E. Brown Jr., Network for Earthquake Engineering Simulation, or NEES, providing world-class experimental facilities at 15 U.S. academic institutions with the accompanying cyber infrastructure. NEES provides a platform for collaborative earthquake engineering research, education, and outreach.

NIST links NSF basic research with FEMA's implementation activities. NIST is rebuilding its earthquake engineering research capabilities to bridge the research-to-implementation gap.

The NIST program supports earthquake engineering practice and building code development, develops the technical basis for performance-based seismic design, and makes technologies available to the design and construction communities.

FEMA is NEHRP's primary implementation arm and works with the practitioner community, the American Society of Civil Engineers, and the International Code Council to support model building code development. These codes have been adopted in whole or in part in all 50 states. FEMA is developing the next generation of the NEHRP recommended provisions for future use in model building codes. In this work, FEMA works closely with the Survey to incorporate new hazard mapping into recommended building code provisions. FEMA also provides technical and financial assistance to the states and to multi-State consortia to increase earthquake awareness and support training for State and local officials.

In summary, there is still much to be learned about earthquakes and their impacts. This is true both in the scientific fields and in the engineering disciplines. What we know highlights the continuing need for greater preparedness and mitigation if the NEHRP vision for the Nation is to be realized.

The four NEHRP agencies have a strong partnership, both among themselves and with the Nation's earthquake professional community. We intend to strengthen these partnerships while looking toward the future.

This concludes my remarks, sir, and I am happy to answer any questions you may have.

[The prepared statement of Dr. Hayes follows:]

PREPARED STATEMENT OF JOHN R. HAYES, JR.

Introduction

Chairman Wu, Ranking Member Smith and Members of the Subcommittee, thank you for inviting me to testify on the reauthorization of the National Earthquake Hazards Reduction Program (NEHRP). My testimony focuses not only on the National Institute of Standards and Technology (NIST) but also on the four-agency NEHRP partnership. NEHRP's partner agencies are NIST, the Federal Emergency Management Agency (FEMA), the National Science Foundation (NSF), and the U.S. Geological Survey (USGS). It is also very important to note that the NEHRP partnership extends far beyond the four statutory federal agencies to include other federal agencies, State and local governments, professional organizations, model building code and standards organizations, and earthquake professionals in the private sector and academia. Without this extended network of organizations and individuals, NEHRP would not fulfill its statutory responsibilities effectively.

In the five years since the last NEHRP reauthorization hearings were conducted, the U.S. has experienced a relatively quiet period of seismic activity. However, seismologists agree that large, damaging earthquakes in the U.S. are inevitable and unpredictable. Globally it has been anything but quiet, from the December 2004 magnitude-9 earthquake and ensuing tsunami that devastated the Indian Ocean region to the May 2008 magnitude-7.9 earthquake in the Sichuan province of China, in which tens of thousands of people lost their lives. Both events followed decades or even centuries of quiescence on the faults where they struck and are sadly sobering reminders of the unexpected tragedies that can occur.

The USGS has recently issued updated assessments of earthquake hazards in the U.S. that provide appropriate perspectives for us. In 2008, the USGS, the Southern California Earthquake Center (SCEC), and the California Geological Survey (CGS), with the support from the California Earthquake Authority (CEA) jointly produced a forecast of a 99+ percent certainty of California's experiencing a magnitude-6.7 or greater earthquake within the next 30 years. It is noteworthy that the recent L'Aquila earthquake in central Italy, in which over 300 people perished, had a magnitude of 6.3, slightly less than that which is postulated for California.

While concern for future earthquake activity is always great in California and elsewhere along the West Coast, earthquakes with magnitudes ranging from 5 to 6 struck Nevada and along the Illinois-Indiana border in 2008, the latter generating reports of shaking in sixteen states and into Canada.

As you know, NEHRP was established by Congress in 1977, to "reduce the risks of life and property from future earthquakes in the United States." The Program is predicated on the belief that earthquakes are inevitable and will occur without warning, but that there is much the Nation can do to minimize their consequences. The NEHRP agencies strive to perform the needed research and then translate the research results into actions that accomplish that goal. During the past five years, the NEHRP agencies have worked diligently to ensure that United States (U.S.) citizens are less threatened by devastating earthquakes.

NEHRP Organization

The last reauthorization of NEHRP (P.L. 108–360) directed that a number of changes in program organization, leadership, and reporting be made: establishing NIST as the Program Lead Agency, directing the creation of the NEHRP Interagency Coordinating Committee (ICC) and the external Advisory Committee on Earthquake Hazard Reduction (ACEHR), and requiring a new Strategic Plan and annual Program reports.

Interagency Coordinating Committee

Prominent among these changes has been the creation of the NEHRP ICC, which is composed of the Directors/Administrators of the four Program agencies and the Directors of the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP). The ICC is chaired by the NIST Director. The ICC

has met on eight occasions and has conducted informal exchanges of information on other occasions—the ICC has been very actively engaged in Program leadership. The creation of the ICC has resulted in a significant increase in program visibility in each agency and in the Executive Office of the President, and it has elevated key interagency decisions to be discussed and agreed to at the agency leader level. While many program decisions can be made at the working level, the direct involvement of the agency leaders has greatly improved program coordination and efficiency.

For example, as a part of the process of preparing a new Strategic Plan for the program, the ICC asked the non-statutory working level Program Coordination Working Group (PCWG) to assess the then-existing Strategic Plan and ongoing program activities, so that "gaps" could be identified for inclusion in the new plan.

The ICC has also actively overseen the development of NEHRP's annual reports and, most importantly, the development of the new Strategic Plan for the program that was released in October 2008. For each of these documents, the PCWG has briefed the ICC formally at one or more of its meetings. The ICC members viewed the significance of the Strategic Plan to be so great that it remained fully engaged with its development throughout the period of intense activity that went into its preparation.

Advisory Committee on Earthquake Hazards Reduction

Paralleling the formation of the ICC was the requirement for the establishment of the Program advisory committee. The ACEHR was formed initially in 2007 and consists of 16 leading earthquake professionals from across the U.S., from all walks of the non-federal sector. The ACEHR has 15 appointed members and one ex officio member, the Chairperson of the USGS Scientific Earthquake Studies Advisory Committee (SESAC), an advisory body established by the 2000 *Fire Administration and Earthquake Hazards Reduction Authorizations* (P.L. 106–503). While the ACEHR by statute provides its advice to the NIST Director, the committee is truly engaged across NEHRP, from fundamental seismological issues to building code implementation. In addition, social scientists on the committee ensure that economic issues and human factors are being considered by the NEHRP agencies. The ACEHR submitted its first formal report to the ICC in 2008 and followed that report with a May 2009 letter report. The ICC is committed to thoughtful consideration of these reports.

Lead Agency

Accompanying the statutory requirements for creating the ICC and ACEHR, the 2004 reauthorization designated NIST as the NEHRP Lead Agency. To address this requirement, NIST established a formal NEHRP Secretariat office in early 2006. The Secretariat is responsible for supporting the activities of both the ICC and ACEHR. In addition, the Secretariat coordinates the working-level activities of the agencies and produces required reports in conjunction with the staff-level Program Coordination Working Group (PCWG), which includes representatives of the four program agencies. At this level, NEHRP also links its activities to those of the broader National Science and Technology Council Subcommittee on Disaster Reduction. While NIST "leads" NEHRP activities through the Secretariat, it is only with the outstanding teamwork of all the agencies working together that NEHRP accomplishments occur. There is a genuine camaraderie, sense of common purpose, and dedication to improving earthquake safety among the agency representatives.

NEHRP Strategic Plan

A major recent accomplishment of the program is its new Strategic Plan that was released in late 2008 (*http://www.nehrp.gov/pdf/strategic_plan_2008.pdf*). The new plan was developed during two years of intense, thoughtful work by the PCWG. The ICC and ACEHR provided review and input. The NEHRP agencies initiated the plan development in 2006 by soliciting public comments on the previous plan that had been released in 2003 and again, at the end of the plan development period, solicited public comments on the pre-final draft before publishing its final version.

Vision

The Strategic Plan sets a NEHRP vision:

> *A nation that is earthquake-resilient in public safety, economic strength, and national security.*

The NEHRP agencies see this vision as one that sets a fresh course for NEHRP. This course recognizes the importance of not only improving public safety in future earthquakes but also enhancing our economic strength and national security through greater resilience. For example, if a future southern California earthquake

severely damaged the ports of Los Angeles and Long Beach, as happened to the ports of Kobe, Japan, in 1995, there would be national economic implications. Similarly, if a future New Madrid-type earthquake in the Central U.S. severely damaged one or more major Mississippi River crossings in the Saint Louis to Memphis region, transcontinental highway and rail transportation, as well as oil and natural gas transmission could be severely disrupted. Working with its partners in both the federal and non-federal sectors, NEHRP can and should provide tools to assist the government and corporate entities who must address those challenges.

The new vision not only sets this broad focus beyond safety alone but also recognizes the national need for improving our resilience in the face of future damaging earthquakes. While many detailed definitions of resilience exist, the NEHRP agencies can simply view it as the Nation's capability to maintain its functions or recover from future earthquakes. While NEHRP's best intentions are to provide State and local governments, and the private sector, with the tools they need to improve the survivability of their infrastructure and real property in future earthquakes, future earthquakes will still inflict serious damage. Even though response and recovery activities are not the direct statutory focus of NEHRP, NEHRP does play a role in providing the means for improving response and recovery capacity. For example, led by FEMA and USGS, the NEHRP agencies are engaging in scenario demonstration projects, such as the 2008 *Great Southern California Shakeout* activity. These projects serve to catalyze both pre-earthquake mitigation measures and post-earthquake response and recovery activities to State and local leaders.

Plan Structure

The strategic plan sets three overarching program goals, each with four or more key objectives—improve understanding of earthquake processes and impacts; develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society-at-large; and improve the earthquake resilience of communities nationwide. The goals are not agency-specific. Indeed all three goals involve synergies among the agencies. In addition to the goals and objectives, the plan sets out nine areas of strategic priority for the program, areas of great importance to the Nation that will be emphasized as resources become available to address them.

The NEHRP strategic plan also outlines a number of significant guiding principles. These principles are not so much specific objectives as they are philosophies that the NEHRP agencies agree must be employed as NEHRP advances to achieve the new vision. Three of those principles are highlighted briefly here. First, the NEHRP agencies will continue and enhance their cooperation with the earthquake professional community, those professionals in all walks of life who deal with earthquake-related issues. NEHRP has enjoyed the benefits of a long partnership with this community, and attention to this relationship is critical. Second, the NEHRP agencies will seek, within their designated mission areas, closer ties to the international community. Not only can the NEHRP-developed technologies be applied to help others, but also the U.S. can also learn from advances that are being made abroad. Finally, the NEHRP agencies will seek to foster synergies among disciplines as well as with those who work with other hazards, such as wind, flood, and fire. Current examples of such synergistic work include:

- NSF has pioneered numerous inter and multi-disciplinary activities in its NEHRP-related programs.
- FEMA has extended its earthquake loss estimation program, Hazards U.S. (HAZUS), to include flood and other hazards.
- The USGS has launched multi-hazard demonstration projects in southern California and the Pacific Northwest.

In looking at interactions with leaders in multi-hazard areas, the NEHRP agencies are aware of both the similarities, significant differences and linkages that exist among the hazards. Most of the technical issues that are closely tied to monitoring hazard occurrence, assessing the resulting risks, and developing tools, standards, and guidelines for design and construction differ substantially from hazard to hazard, making direct interactions at that level difficult. However, there are opportunities for the coordination of some NEHRP activities with those that are ongoing for other hazards. There are similarities in disaster response that can and should be shared with those who work in the other hazard areas (FEMA), and there are similarities in structural response mechanisms that occur in earthquakes and in blast or impact situations (FEMA, NIST, NSF). Some key linkages provide some excellent opportunities for multi-hazard cooperation, e.g., tsunami warnings for such events that are caused by earthquakes (USGS-provided data used by the National Weather Service) and structural fire effects from any source (NIST). The NEHRP agencies

are also aware of the 30+ year history of organized NEHRP interaction with the earthquake professional community and State and local governments; this provides much organizational experience that can be shared with those working in other hazards-related fields.

Recent NEHRP Accomplishments-Fostering Technology and Knowledge Transfer

The NEHRP agencies have worked both individually and collectively in recent years on initiatives that are intended to improve the Nation's earthquake resilience. Recent NEHRP annual reports provide substantial information regarding program activities. Examples are highlighted below.

Workshops

In 2007 and 2008, the four partner agencies worked with the national earthquake safety community, through a series of workshops, to identify future research and implementation needs that support the new strategic plan. The first such workshop addressed research and implementation issues associated with evaluating and strengthening existing buildings. Three subsequent workshops addressed research needs to support the full implementation of Performance-Based Seismic Design, which was mentioned prominently in the last reauthorization; the basic scope of a national Post-Earthquake Information Management System that would support both organized post-earthquake reconnaissance activities and the development of a national electronic repository of information gathered through such activities; and, guidance for communities of all sizes on how to formulate and conduct earthquake scenarios that meet community objectives. These workshop activities have effectively fostered communication and cooperation among the agencies and between them and the earthquake practitioner community. The agencies are strongly committed to other such workshops in the future.

The NEHRP agencies form a team, with each member agency having key roles in the successful development and transfer of new knowledge into practice. Below are examples of successful implementation of knowledge transfer from one NEHRP agency to others:

USGS

The USGS is the applied Earth science component of NEHRP. USGS efforts are complemented by basic research projects that are supported by NSF. USGS reports on earthquake size, location, and impacts; develops seismic hazard assessment maps and related mapping products; builds public awareness of earthquake hazards; and supports targeted research to improve monitoring and assessment capabilities. USGS carries out these responsibilities through partnerships with the other NEHRP agencies, State and local governments, and university researchers.

The USGS supports targeted research activities, working in concert with NSF. As an example of its current research efforts, Light Detection and Ranging (LIDAR) topographic imaging is being used to map fault scarps that are hidden by vegetation and were previously unknown. This activity has revolutionized our understanding of earthquake hazards in the Pacific Northwest.

Monitoring

Since the last reauthorization of NEHRP, the USGS has made great strides in its delivery of comprehensive earthquake information from monitoring systems, both in the U.S. and worldwide. In the U.S., monitoring is accomplished via the developing Advanced National Seismic System (ANSS), which has added enough modern seismic instruments to rapidly deliver instrument-based shaking intensity information in five high-risk metropolitan areas out of 26 planned and is now deployed at a total of 822 stations. The ANSS is a partnership between the USGS and its State and university partners. Internationally, USGS works in partnership with NSF and the Incorporated Research Institutions for Seismology (IRIS) to utilize the Global Seismographic Network for earthquake monitoring. Complementing the field monitoring capability is the USGS National Earthquake Information Center (NEIC), which assimilates all monitoring data on a 24/7 basis and issues rapid reports of potentially damaging earthquakes to key federal, State, and local institutions, as well as to an electronic mailing list of over 100,000 users. Since the last reauthorization, USGS has implemented full on-site 24/7 operations at NEIC and developed products such as the Prompt Assessment of Global Earthquakes for Response (PAGER) system that provides rapid estimates of the population exposed to strong shaking and delivers that to aid agencies, emergency managers, and others who use it to prioritize response activities.

Mapping

In 2008, USGS released new national seismic hazard maps that incorporate the most recent field observations and research results. These maps show that earthquakes are serious threats in 46 states. The maps are being used now to develop design maps for national model building codes. FEMA and USGS closely collaborate on these activities, ensuring that the most recent and technically sound hazard information is considered by the American Society of Civil Engineers (ASCE) and the International Code Council (ICC). The new maps differ from older maps primarily in their incorporation of recent research results in areas near significant known faults. The new research has resulted in ground-motion models that increased expected shaking in western Washington and Oregon, near the Cascadia subduction zone, but decrease expected shaking in the Central and Eastern U.S. somewhat. In many areas of the western U.S., the new models lower expected shaking levels for taller, "long-period" buildings. The USGS is also developing more detailed urban hazard maps for various areas; such maps have been released recently for Memphis and Seattle and are currently underway for St. Louis and Evansville, Indiana.

Scenario Exercises

Also in 2008, the USGS, CGS, and SCEC produced a plausible scenario of a rupture of the southern end of the San Andreas fault that could result in about 1,800 deaths, 50,000 injuries, and economic losses exceeding $200 billion in the greater Los Angeles area. This scenario formed the basis for the *Great Southern California Shakeout* earthquake preparedness and response exercise in late 2008. The *Shakeout* was supported by FEMA, NSF, USGS, and numerous State and local organizations. Over five million Southern California residents participated in the *Shakeout,* making it the largest public preparedness event ever held in the U.S. Plans are underway for a statewide version in 2009.

NSF

NSF provides the basic research arm for NEHRP, supporting research that addresses Earth science, geotechnical and structural engineering, lifeline engineering, the social sciences, and integrating all these disciplines.

NSF supports fundamental research related to earthquake processes: seismology, geodesy, rock mechanics, paleoseismology (geologic studies of prehistoric earthquakes), structural geology, and relevant theoretical, modeling, and laboratory projects. Recent outcomes from these programs range from explanatory mechanisms for episodic tremor and slip observed along plate boundaries around the world to insight into the slip differential across the southern San Andreas Fault using interferometric synthetic aperture radar imagery, global positioning systems, and seismic measurements. This work has substantially improved the description and understanding of the strain building up along major plate boundary faults such as the southern San Andreas Fault and the San Jacinto Fault.

The Southern California Earthquake Center (SCEC) is a five-year program funded by NSF and USGS. SCEC's main goal is to produce a physics-based understanding of Southern California earthquake phenomena through integrative study of tectonics, active fault systems, fault zone processes, fault rupture and ground motions. SCEC scientific accomplishments have been incorporated into practical products, such as the USGS National Seismic Hazard Maps, as well as new seismic attenuation relations developed by the Next Generation Attenuation (NGA) Project at the Pacific Earthquake Engineering Research (PEER) Center. NSF supports SCEC to advance seismic hazard research using high-performance computing, with the aim of utilizing petascale computing facilities when they become available in the 2010–2011 timeframe. SCEC's Petascale Cyberfacility for Physics-based Seismic Hazards Analysis (*PetaSHA*) project has goals to reach earthquake simulations at frequencies up to 10Hz, including development of a dynamic rupture platform (*DynaShake*) that can generate kinematic source descriptions that emulate dynamic descriptions. *DynaShake* will be used to develop kinematic rupture models for several observed earthquakes (for validation), as well as several large San Andreas Fault ruptures and a large reverse faulting earthquake.

NEES

Noteworthy among NSF activities since the last NEHRP reauthorization has been the completion of construction and initial operations of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). NSF completed the $82 million Major Research Equipment and Facilities Construction for NEES in September 2004, developing world-class experimental facilities at 15 academic institutions across the U.S. and accompanying cyberinfrastructure. The testing facilities

include seismic shake tables, geotechnical centrifuges, a tsunami wave basin, large strong-floor and reaction-wall facilities with unique testing equipment, and mobile and permanently installed field equipment. The network's cyberinfrastructure technology links the facilities via the *Internet2* grid, forming the world's first prototype of a distributed "virtual instrument." The cyberinfrastructure also provides a national repository for experimental data, as well as numerical simulation and collaborative tools.

NEES plays a major role in NEHRP. The NEES multi-user facility concept serves a unique role among NEHRP agency investments for basic earthquake engineering research, providing diverse experimental capabilities, substantial user support, emphasis on education and outreach, and a university environment characterized by openness for academic, industry, and government use. NSF works with the other NEHRP agencies to periodically update the NEES earthquake research agenda. NEES has promoted change in the research culture for the earthquake engineering community through open access to unprecedented experimental capabilities, collaboration with experimental facility staff to develop formal testing protocols, archival of all experimental data in a community data repository for reuse by other investigators, and a new generation of students trained in advanced experimentation techniques and analytical modeling.

NSF supports research utilizing NEES through annual program solicitations. Many of these NSF-supported projects include practitioner and industry partners to help design experimental and analytical investigations and to speed technology transfer. NEHRP agency partners and other federal agencies support projects to transfer NEES research findings into technical briefs for practitioners, performance-based seismic design (PBSD) guidelines, and seismic provisions. For example, NIST plans to utilize NEES research facilities in any future earthquake-related testing that it conducts.

Research using NEES is creating the underpinning knowledge for PBSD guidelines; expanding the knowledge base for incorporating high-performance materials and advanced technologies in buildings, bridges, and critical utility systems; and developing new concepts for structural systems. NEES research also provides knowledge to mitigate the effects of ground failure caused during earthquakes by liquefaction, lateral spread, landslide, and soil failure at foundations. NEES experimental data are leading to more comprehensive analytical models for structures subject to near-collapse seismic loading. Research at the tsunami wave basin has produced the largest experimental data set to date for three dimensional granular landslide-generated tsunamis.

NSF's Memorandum Concerning Cooperation in the Area of Disaster Prevention Research with the Japanese Ministry of Education, Culture, Sports, Science, and Technology enables U.S. researchers to use both NEES and Japan's Earth Defense (*E–Defense*) shake table, the world's largest shake table, to simulate seismic performance on large- to full-scale models with geotechnical and structural innovations. The first NSF-supported NEES research project to use *E–Defense*, a project on multi-story wood frame behavior, is commencing at *E–Defense* in summer 2009.

As of September 2007, the three NSF-supported research centers—the Multidisciplinary Center for Earthquake Engineering Research (MCEER) led by the University at Buffalo, the Mid-America Earthquake (MAE) Center led by the University of Illinois at Urbana-Champaign, and the PEER Center led by the University of California, Berkeley—completed 10 years of NSF support. The centers are continuing through various combinations of university, State, and private sector support, and with other federal funding. Through NSF support, these centers have made major contributions to the development of performance-based seismic design; improved fundamental understanding of seismic performance of structures ranging from buildings, bridges, and acute care facilities to critical utility lifelines; and developed advanced technologies to improve earthquake mitigation and response.

NSF has continued to provide support, along with other federal agencies, for the Natural Hazards Center at the University of Colorado, Boulder. The Center's annual workshop each July brings together leading U.S. natural hazards researchers, policy-makers, and practitioners. This is the major national forum for linking the producers of research with appropriate user communities.

NIST

In 2006 and 2007, NIST devoted significant attention to the task of establishing the NEHRP Secretariat and initiating the various organizational functions that have already been discussed. A critical part of the NIST effort has been the establishment of the NEHRP web site (*www.nehrp.gov*) that contains much information about the Program, links to all of the NEHRP agency sites, and links to other organizations that are involved with earthquake-related research and implementation

issues. Efforts are now underway to incorporate an electronic clearinghouse of documents produced by NEHRP activities within the web site. NIST also recently initiated a NEHRP-wide study by the National Research Council (NRC) that will provide a broad roadmap for the NEHRP agencies to consider as they implement the new Strategic Plan. The NRC study assembles a broad panel of national experts in all aspects of earthquake risk reduction to help identify and prioritize possible activities that could be considered to achieve the objectives set out in the NEHRP Strategic Plan.

NIST's technical role in the Program may be summarized as one of linking the basic research products that come from NSF-supported university research with the implementation activities that are largely led by FEMA. Commencing in 2007, in a strong commitment to the Program, NIST began to rebuild its capabilities in the earthquake research arena, which had been largely dormant for a number of years, to bridge the research-to-implementation gap. This rebuilding effort has been enlarged for 2009. NIST has formed its research program around several key theme areas: providing technical support for the earthquake engineering practice and building code development process; developing the technical basis for performance-based seismic design (PBSD); supporting the development of technical resources that improve earthquake engineering practice; and, making evaluated technologies available to practitioners in the design and construction communities. These activities are consistent with the NIST mission of serving the measurement and standards needs of the building and fire safety industries. NIST is a critical source of metrics, models, and knowledge for predicting the extent of damage from natural and man-made hazards, mitigating their impact, and helping to enhance the disaster resilience of communities and the built environment.

In 2007, NIST established a partnership with the NEHRP Consultants Joint Venture, which links NIST with the Nation's leading earthquake engineering researchers and practitioners. The first product of this effort was released in 2008, a short *techbrief* document for structural engineers who design reinforced concrete frame buildings in areas of high seismic activity. Several additional projects are ongoing. In addition, NIST began to rebuild its in-house capabilities in 2008 by hiring new earthquake research staff members; this process continues today, with staff increases anticipated in 2009 and 2010, contingent on available resources.

Given the unique nature of the necessary interaction between NIST and FEMA in fulfilling their respective roles, the two agencies have formed a special partnership with their programs that involves complete, frequent exchanges of project information and in some instances actual direct collaboration on projects that involve complementary topic areas.

FEMA

FEMA acts as NEHRP's primary "implementation arm," though the other agencies contribute to Program implementation efforts. Similar to NIST, FEMA has demonstrated its commitment to NEHRP through a significant increase in support in 2009.

FEMA has a very prominent NEHRP leadership role in working with the practitioner community, the ASCE, and the ICC to support the development of model building code provisions. As it has done for many years, FEMA is working with the Building Seismic Safety Council (BSSC) to develop the next generation of the *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* that will be available in 2010 for future use in model building codes. USGS supports the development of the *Recommended Provisions* with its hazards mapping activities.

While working on this document for the future, FEMA is also working directly with the model building code organizations to assist in the development of new seismic provisions for the 2009 editions of the International Codes, or "I–Codes," that are promulgated by the ICC. The I-Codes have been adopted in part or whole by all 50 states, standardizing safe design practices nation-wide. At the ICC's initial code change hearings for the 2009 edition, FEMA staff and contractors attended various portions and provided testimony on many proposed code changes for the *International Building Code* (IBC), the *International Existing Building Code* (IEBC) and the *International Residential Code* (IRC). This testimony included supporting proposed code changes submitted by FEMA, proposed code changes where FEMA worked with the proponents, and proposed code changes that other parties submitted. In some instances, FEMA spoke in opposition to proposed code changes that weakened the code.

While working with the national model building code and standards organizations on issues that are sufficiently mature to be considered for building code adoption, FEMA also continues to support projects to develop guidelines for designers. It is

in this area that FEMA is working very closely with NIST, and this partnership and the resulting development, publication, dissemination, and promotion of building design and construction materials are signature elements of the NEHRP. In the past 30 years, FEMA has developed and published over 200 earthquake design guidance publications on all aspects of earthquake mitigation, including: seismic design and construction of new buildings; the retrofitting of existing hazardous structures, including the need for affordable seismic retrofitting techniques; and other related structural and non-structural issues. FEMA also conducts or supports related outreach activities to promote training courses and publications.

Existing buildings pose a much greater risk than new buildings, as most were constructed prior to current building codes and many are collapse hazards. FEMA has published an entire series of publications on existing buildings, from rapid screening of many buildings to guidance on seismic rehabilitation of an existing hazardous building.

In another example, in 2008, FEMA completed the 50 percent draft of the *Guidelines for Seismic Performance Assessment of Buildings,* and an accompanying Performance Assessment Calculation Tool (PACT), which is the first phase of the multi-year project to develop the Next-Generation Performance-Based Seismic Design (PBSD) Guidelines for New and Existing Buildings. The project is based on the *Next-Generation Performance-Based Seismic Design Guidelines, Program Plan for New and Existing Buildings,* published by FEMA as FEMA 445. As part of the PBSD project, FEMA also recently published a document that provides methodologies on how to test the performance of building components, *Interim Protocols for Determining the Seismic Performance Characteristics of Structural and Nonstructural Components* (FEMA 461). This publication was developed in concert with the three national earthquake engineering research centers that NSF supported through the end of 2007.

A prominent new FEMA public outreach effort began in 2008 with the new *QuakeSmart* initiative, which is designed to encourage business leaders and owners in areas that are at risk from earthquakes to take actions that will mitigate damage to their businesses, provide greater safety for customers and employees, and speed recovery if an earthquake occurs. The goal of *QuakeSmart* is to build awareness within the business community of earthquake risks and to educate businesses, particularly small and emerging ones, on the relatively simple things they can do to reduce or mitigate the impacts of earthquakes, thus supporting community preparedness. The effort began with a series of Community Forums in four cities in the Midwest and on the West Coast. Further forums are scheduled for late 2009.

To support and increase the adoption of their earthquake resiliency measures, the NEHRP agencies, led primarily by FEMA, maintain strong partnerships with other earthquake and hazards-related agencies, State and local governments, academia, the research community, code enforcement officials, design professionals, and the remainder of the private sector.

FEMA provides technical and financial assistance to states and multi-State consortia to increase awareness of the earthquake hazard and to foster plans to reduce seismic vulnerability. To provide State financial assistance, FEMA administers the all-hazards Pre-Disaster Mitigation (PDM) Grant Program for states and communities; the Hazard Mitigation Grant Program (HMGP), an all-hazards post-disaster grant program; and the Emergency Management Performance Grants (EMPG) Program, which provides grants to states to improve emergency management performance and is administered by FEMA's Preparedness Directorate.

FEMA also supports a series of multi-State consortia and organizations, including the Cascadia Regional Earthquake Working Group (CREW), which serves states in the Pacific Northwest affected by the Cascadia Subduction Zone and related faults; the Central United States Earthquake Consortium (CUSEC), which serves the states impacted by the New Madrid seismic zone; the Northeast States Emergency Consortium (NESEC), which serves northeastern states on a multi-hazard basis; and the Western States Seismic Policy Council (WSSPC). FEMA's support to these organizations is in the form of grants to support earthquake-related outreach and educational activities that promote earthquake mitigation and awareness.

FEMA also funds the National Earthquake Technical Assistance Program (NETAP), a program to support earthquake mitigation training for State and local officials. Through the National Earthquake Technical Assistance Program (NETAP), FEMA supports development of training curricula on earthquake mitigation topics and provides courses for State and local officials and businesses throughout the U.S.

To improve education and awareness, FEMA has co-sponsored series of informational conferences, including the National Earthquake Conference held in St. Louis, MO in September 2004 and in Seattle in April 2008, as well as the 100 Year Anni-

versary of the 1906 San Francisco Earthquake. In total, several thousand individuals attended numerous presentations on earthquake-related topics.

In a project closely related to its other NEHRP efforts, FEMA completed development and publication of its *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis.* This document was jointly funded by FEMA and NOAA. Tsunami safety is a critical issue for several coastal communities along the West Coast of the U.S. that are vulnerable to tsunami. The States of Oregon and Washington have already expressed interest in using this publication.

Conclusion

Damaging earthquakes, while infrequent in the U.S., can be among the costliest natural disasters, measured both in terms of economic impact and lives lost or disrupted. There is still much to be learned about earthquakes and their impacts. This is true both in the scientific fields and in the engineering disciplines. What we do know highlights the continuing need for greater preparedness and mitigation, if the NEHRP vision for the Nation is to be realized. The four NEHRP agencies have a strong partnership, both among themselves and with the Nation's earthquake professional community that continues to focus on that vision.

Chairman Wu, thank you again for the opportunity to testify on NEHRP activities. This concludes my remarks. I will be happy to answer any questions you may have.

BIOGRAPHY FOR JOHN R. HAYES, JR.

John Hayes joined the Building and Fire Research Laboratory in early 2006. He is the Director of NEHRP. NEHRP is the Federal Government's program to reduce risks to life and property from earthquakes. NEHRP consists of four federal agencies: FEMA, NSF, USGS, and NIST. As Director, Hayes provides overall program management, coordination and technical leadership; strengthens program effectiveness by facilitating implementation of earthquake risk mitigation measures; and builds and maintains effective partnerships with NEHRP agencies and stakeholders in industry, academia and government. Specific duties include strategic and management plan development and implementation; program evaluation and performance measurement; budget review, guidance and coordination; preparation and submission of coordinated annual program budgets; submission of an annual report to Congress on consolidated program priorities, budget and results, including an assessment of program effectiveness; information dissemination on earthquake hazards and loss-reduction measures; and related interagency programs and policies.

Hayes joined NIST after serving since 1988 as leader of seismic and structural engineering research at the U.S. Army Engineer Research and Development Center's Construction Engineering Research Laboratory (CERL) in Champaign, IL. At CERL, Hayes was actively involved in earthquake engineering research for the U.S. Army Corps of Engineers. He also collaborated extensively with the earthquake engineering program at NSF, including work within the Mid-America Earthquake Center, and has been directly involved with a number of significant earthquake mitigation projects for FEMA. Working with key personnel at USGS, Hayes helped develop the seismic provisions for the American Society of Civil Engineers' ASCE 7–05 standard and a new Department of Defense tri-services seismic design manual.

Prior to his tenure at CERL, Hayes was Research Civil Engineer and Senior Scientist at the Engineering Research Division of the U.S. Air Force Engineering and Services Laboratory (1984–1988); Structural Engineer at the U.S. Air Force Armament Division (1982–1984); Assistant Professor of Civil Engineering at the Virginia Military Institute (1980–1982); Civil Engineer and NATO Infrastructure Staff Officer at the Headquarters U.S. Air Forces in Europe (1977–1980); and Civil Engineer Officer at Tinker AFB, OK (1975–1977).

Hayes is a retired Lieutenant Colonel in the U.S. Air Force Reserves and is a registered Professional Engineer in Florida and Virginia.

Education:

Ph.D., Civil Engineering, 1998, University of Illinois at Urbana–Champaign

M.E., Civil Engineering, 1975, University of Virginia (*Tau Beta Pi*)

B.S., Civil Engineering, 1973, Virginia Military Institute (Distinguished Graduate)

Chair WU. Thank you, Dr. Hayes. Mr. Murphy, please proceed.

STATEMENT OF MR. KENNETH D. MURPHY, IMMEDIATE PAST PRESIDENT, NATIONAL EMERGENCY MANAGEMENT ASSOCIATION (NEMA); DIRECTOR, OREGON OFFICE OF EMERGENCY MANAGEMENT

Mr. MURPHY. Thank you, Chair Wu and Ranking Member Smith, and distinguished Members of the Subcommittee for allowing me to testify today. In my statement, I am representing the National Emergency Manager's Association who are members of State emergency management directors in the states. As the Committee considers reauthorization of the NEHRP program, NEMA supports the program's reauthorization as a vital program that helps states prepare for earthquake specific hazards.

There are four key areas that I want to highlight today, challenges faced by emergency managers in preparing communities for earthquakes and other natural hazards, support for reauthorization of the NEHRP program, differences in preparing for hazards, and tools and technology for emergency managers.

The challenges we face as emergency managers are numerous challenges at each level of government and the private sector. I would be remiss if I did not state for the record that financial assistance to address earthquake hazards has been, and always will be, a challenge. Each state, city, county, tribal nation, and territory must deal with either consistent disasters, such as hurricanes or wildfires, which usually provide greater emphasis and support to be prepared for these type of events, or they have to deal with very infrequent disasters which lead to a lack of preparedness, which usually directs emphasis to other issues that are relevant and must be dealt with. Earthquakes are high consequence infrequent events that are often difficult to gain attention.

As you stated, Mr. Chair, the Northridge Earthquake, with the deaths, the injuries, and the billions of dollars, just happened in a few minutes.

The National Earthquake Hazards Reduction Program provides funding allowing for effective practices and policies to earthquake loss-reduction and accelerates their implementation. This program is currently authorized at $191 million for fiscal year 2009 and authorization expires in September of this year. However, according to the Central United States Earthquake Consortium, NEHRP funding has remained level since 1992, so we have lost considerable value over time for the investments made to build preparedness capability and research tools. NEHRP improves techniques to reduce seismic vulnerability of facilities and systems. NEHRP improves seismic hazard identification and risk assessment methods and their use and improves the understanding of earthquakes and their effects. We think the program must remain singularly focused on earthquakes. FEMA should maintain the NEHRP program uses for all four phases of emergency management, preparedness, response, recovery, and mitigation. FEMA should also ensure the program maintains both a State focus and a multi-State focus since earthquakes could hit multi-State regions, and as we have learned from recent hurricanes that our Nation relies on mutual aid assistance in response to disasters.

NEMA supports the creation of the Advisory Committee for NEHRP that was created in the reauthorization of 2005 and appre-

ciates that emergency management is represented on that Committee and hope that the Committee continues.

The NEHRP plan and activities do align with local governments. As NEHRP has evolved during this reauthorization, thought should be given to focus on specific geographic areas, which would be of great benefit to the local needs and preparedness activities. While NEHRP is a valuable program for emergency managers, it is difficult sometimes to track the program's funding year to year, since the program is shared by four separate agencies and often buried in operational accounts for these agencies. Having a clear line item for NEHRP would assist in tracking the funds for the program and gaining more visibility before Congress, the Administration, and stakeholders at the State and local level who are charged with preparing for earthquakes or providing technological expertise for the program.

The most significant issue concerning earthquakes is that earthquakes are no-notice disasters. Many other disasters do provide some types of advanced notice and warning, not all. Similar to other disasters, emergency managers really do not know how severe or how long an earthquake will last. Earthquakes must be planned for in the worst-case scenario, as emergency responders will not know exactly who is alive, who is injured, how large an area is affected initially, and how much damage you have really suffered. Emergency managers also have to be prepared for aftershocks, and on the coastal areas we have to plan for tsunamis. All of these factors make planning for earthquakes unique and specific for different geographical areas.

In preparing for earthquakes it is important to have tools such as HAZUS, which is a modeling tool from FEMA, but I believe that this tool needs more refinement and to be specific to earthquakes and tsunamis allowing more specific modeling for each jurisdiction allowing governments to better implement preparedness response and recovery and mitigation programs. Geologists and seismologists need more research into the prediction of earthquakes and more sensors in the ground to give us warning and scientific data on Earth's movement during earthquakes.

Applied research that is sponsored in part by NEHRP and its agencies may eventually lead to advancements in exciting new technologies, such as early warning earthquake systems which are vitally important to protecting human life and critical infrastructure as well as guiding response efforts.

In conclusion, NEMA supports NEHRP reauthorization and looks forward to working with the Committee to enhance the program. If you have any questions, Mr. Chair, I will be available.

[The prepared statement of Mr. Murphy follows:]

PREPARED STATEMENT OF KENNETH D. MURPHY

Introduction

Thank you Chairmen Wu and Ranking Member Smith, and distinguished Members of the Subcommittee for allowing me the opportunity to provide you with a statement for the record. I am Ken Murphy, the Immediate Past-President of the National Emergency Management Association (NEMA) and the Director of the Oregon Office of Emergency Management. In my statement today, I am representing NEMA, whose members are the State emergency management directors in the states, the U.S. territories, and the District of Columbia. NEMA's members are responsible to their Governors for emergency preparedness, homeland security, miti-

gation, response, and recovery activities for natural, man-made and terrorist caused disasters. In my state, the emergency management office is responsible for earthquake preparedness, response, recovery, and mitigation and we are actively engaged with the National Earthquake Hazards Mitigation Program (NEHRP).

As the Committee considers reauthorization of the NEHRP program, NEMA supports the program's reauthorization as a vital program that helps states prepare for earthquake specific hazards. The NEHRP program works in concert with critical preparedness functions at FEMA, such as the newer Regional Catastrophic Grant Program and the Emergency Management Performance Grant Program, the only all-hazards preparedness program. Better integration of NEHRP in key activities like mitigation, all-hazards gap analysis, and all-hazards preparedness activities would benefit State preparedness activities and building the capabilities nationally and at the State and local level for catastrophic preparedness.

There are four key areas that I want to highlight today:

1. Challenges faced by emergency managers in preparing communities for earthquakes and other natural hazards;
2. Support for reauthorization of the National Earthquake Hazards Reduction Program;
3. Difference in preparing for the hazards; and
4. Tools and technology for emergency managers.

CHALLENGES FACED BY EMERGENCY MANAGERS

Emergency managers are faced with numerous challenges at each level of government and the private sector. I would be remiss if I did not state for the record that financial assistance to address earthquake hazards has been and always will be a challenge. Each state, city, county, tribal nation, and territory must deal with either consistent disasters, such as hurricanes or wildfires, which usually provide greater emphasis and support to be prepared for these type events or they have to deal with very infrequent disasters which lead to a lack of preparedness, which usually directs emphasis to other issues that are relevant and must be dealt with. Earthquakes are high consequence infrequent events and are often difficult to gain attention. I want to highlight some of the larger events so you get a picture of how earthquakes measure up to other disasters.

- During the Nisqually Earthquake of 2001, one of the largest recorded earthquakes in Washington State history, one casualty and 407 injuries were reported along with the disruption of business, transportation, and government functions for a number of days for extensive inspection, repair, and clean-up efforts. The earthquake was Washington's most expensive and widespread disaster, according to State and federal coordinating officers for the disaster recovery program, totaling over $322 million in federal disaster recovery costs and not including damages to bridges or roadways covered by the Federal Highway Administration System;
- The Northridge Earthquake in California in 1994 was responsible for 72 deaths and over 9,000 injuries and left 25,000 people homeless. The earthquake caused an estimated $25 billion in damage, making it one of the costliest natural disasters in U.S. history. An outbreak of Valley Fever also hit the affected area directly following the earthquake due to the large amount of dust and land movement during the quake and was responsible for three deaths;
- The Loma Prieta Earthquake of 1989 killed 63 people, injured 4,000, and left over 8,000 people homeless. The earthquake caused between $8 billion and $12 billion in damages to critical infrastructure, businesses, and homes;
- The 1906 San Francisco earthquake was estimated as a magnitude 8.3 event, lasting 45 seconds. The casualties as a result of the earthquake and resulting fire are estimated to be above 3,000 and to this day is the greatest loss of life from a natural disaster in California's history; and
- The 1812 New Madrid Earthquake and after-shocks, though not officially recorded is often believed to be the largest seismic activity in U.S. history, and induced shaking strong enough to alarm the general population over an area of 2.5 million square kilometers, affecting territory that is now occupied by over 10 states.

NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM (NEHRP)

NEHRP provides funding allowing for effective practices and policies for earthquake loss-reduction and accelerates their implementation. The program is cur-

rently authorized at $191 million for FY 2009 and authorization expires on September 30, 2009. However, according to the Central United States Earthquake Consortium, NEHRP funding has remained level since 1992, so we have lost considerable value over time for the investments made to build preparedness capabilities and research tools. NEHRP improves techniques to reduce seismic vulnerability of facilities and systems. NEHRP improves seismic hazards identification and risk-assessment methods and their use and improves the understanding of earthquakes and their effects.

The program must remain singularly focused on earthquakes. FEMA also should maintain the NEHRP program's uses for all four phases of emergency management—preparedness, response, recovery, and mitigation. FEMA should also ensure the program maintains both a State focus and a multi-State focus, since earthquakes could hit multi-State regions and as we have learned from recent hurricanes that our nation relies on mutual aid assistance in response to disasters. NEMA supports the creation of the Advisory Committee for NEHRP that was created in the reauthorization in 2005 and appreciate that emergency management is represented on the Committee. We hope that the Committee and emergency management representation will continue.

In addition to NEHRP's scientific and research driven efforts, the program provides coordination with FEMA's Emergency Management Performance Grant (EMPG) that enables states to develop preparedness and response plans as well as increase earthquake awareness. A primary objective of NEHRP is to provide outreach and public education and NEMA strongly supports these efforts at a national, State, and local level. Some of the key NEHRP objectives include development of cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society-at-large; providing guidance and recommendations on codes and ordinances to enhance seismic safety; and improving earthquake resilience of communities nationwide through effective policies.

Some of the key accomplishments by states through NEHRP and FEMA, include preparedness, mitigation, training, and public education.

Training:

- With support from FEMA/NEHRP Washington State EMD trains 250+ personnel annually on mitigation techniques, such as *Rapid Visual Screening of Buildings for Potential Seismic Hazards* as well as response and recovery techniques that include *Post Earthquake Safety Evaluation of Buildings.*

Exercises:

- Major functional exercises have been conducted with the support of FEMA/NEHRP funds. Based on the Seattle Fault Earthquake Scenario, the *Sound Shake 2008* exercise examined serious impacts to the region's transportation and communications systems. This exercise also allowed the state, counties, and cities in the greater Puget Sound region to test their emergency plans and systems. The exercise also provided an opportunity for the region as a whole to continually improve its readiness.

Public Education and Outreach:

- Emergency management continues to promote public awareness of the State earthquake hazards through the annual preparedness month campaigns. Statewide "Drop, Cover and Hold" drills are conducted during both months in an effort to educate citizens on how to respond during an earthquake.
- Awareness and educational videos, including *Earthquake . . . Preparing Your Classroom—How Safe is Your Classroom?* and *Preparing Your Office for an Earthquake,* have been developed and are utilized statewide to inform educators and business owners of non-structural mitigation techniques that can be employed with little or no cost. These instructional videos have been posted online for greater dissemination.

The NEHRP plan and activities do align with local governments. As NEHRP has evolved, during this reauthorization thought should be given to focus on specific geographic areas, which would be of great benefit to the locals needs and preparedness activities.

While NEHRP is a valuable program for emergency managers, it is difficult to track the program's funding from year to year, since the program is shared by four separate agencies and often buried in operational accounts for these agencies. Having a clear line item for NEHRP would assist in tracking the funds for the program and gaining more visibility before Congress, the Administration and stakeholders at

the State and local level who are charged with preparing for earthquakes or providing technological expertise for the program.

EARTHQUAKES VERSE OTHER HAZARDS

The most significant issue concerning earthquakes is that earthquakes are no notice disasters. Many other disasters do provide some types of advanced warning, not all. Similar to other disasters, emergency managers really do not know how severe or how long an earthquake will last. Earthquakes must be planned for in the worst case scenario, as emergency responders will not know who is alive, injured, how large an area is affected, and how much damage you have suffered. Emergency managers also have to be prepared for after-shocks and on the coastal areas we have to plan for tsunamis. All of these factors make planning for earthquakes unique and specific for different geographical areas.

TOOLS AND TECHNOLOGIES

In preparing for earthquakes it is important to have the tools such as HAZUS, which is a modeling tool from FEMA, but I believe that this tool needs more refinement to be specific to earthquakes and tsunamis allowing more specific modeling for each jurisdiction allowing governments to make and implement better preparedness actions. Geologist and seismologist need more research into the prediction of earthquakes and more sensor systems in the grounds to give us some warning and scientific data on the Earth's movement during earthquakes.

Additionally, even though I stated that earthquakes are no notice events it is still important to have technologies that allow jurisdiction to warn their citizens and visitors. NEMA has supported authorization for FEMA's Integrated Public Alert and Warning System (IPAWS) as a component of the warning systems for the emergency management tool-kit. IPAWS is an important technology which is designed to warn individuals through various systems such as text messaging and reverse 911 warnings for an impending event. As emergency managers, we have to be able to tell people what to prepare for, how to react, and what is important when disasters are eminent or have occurred. Having warning systems in place is not enough, if we don't tell them what to do with that information.

Applied research that is sponsored in part by NEHRP and its agencies may eventually lead to advancements in exciting new technologies, such as early earthquake warning, which are vitally important to protecting human life and critical infrastructure as well as guiding response efforts.

CONCLUSION

NEMA supports NEHRP reauthorization and looks forward to working with the Committee to enhance the program. Thank you for the opportunity to testify and we appreciate your support for our nation's emergency management system.

BIOGRAPHY FOR KENNETH D. MURPHY

Currently the Director of Oregon Emergency Management (OEM), Kenneth D. Murphy has been with OEM since July 1999. Early assignments at OEM involved functioning as the Administrative Operations Manager and the Deputy Director for the agency. These initial positions were integral to the overall organizational structure and management of administrative, operational processes and systems for the agency. Mr. Murphy has dealt with legislative issues, human resource management, public information and media liaison, as well as managing the development and implementation of projects to support and enhance the statewide emergency services system infrastructure. Murphy has been the Director of Oregon Emergency Management since April 1, 2003, and was also appointed Director of Oregon's Office of Homeland Security on June 1, 2005.

In 1980, Mr. Murphy left retail furniture business to pursue a full-time career with the United States Army as an active duty Guard/Reserve officer assigned to the Oregon National Guard. Over a period of nineteen years, Mr. Murphy held numerous positions on Company, Battalion, Brigade, Corps and Army staffs. Mr. Murphy's final two assignments included: Chief of the U.S. Army's European Crisis Action Team stationed in Heidelberg, Germany, which had the responsibility to react, manage, coordinate and control emergency situations for 83 European countries; and Director of Military Support to Civilian Authorities for the Oregon National Guard, responsible for the Oregon Guard's coordination and response procedures to State and national emergencies. Murphy retired from active military service in April 1999 as a Lieutenant Colonel with twenty-nine years of service.

Mr. Murphy currently serves on the Governor's Homeland Security Council and Governor's Statewide Inter-operability Executive Council for Oregon. Additionally, he serves as a member of the Board of Director's for the Western States Seismic Safety Policy Council, member of the Board of Directors for the Oregon Regional Maritime Security Coalition, FEMA Region Ten Regional Advisory Council; FEMA Headquarters National Advisory Council and is the immediate past President of the National Emergency Management Association for the United States.

Chair WU. Thank you very much, Mr. Murphy. Professor O'Rourke, please proceed.

STATEMENT OF PROFESSOR THOMAS D. O'ROURKE, THOMAS R. BRIGGS PROFESSOR OF ENGINEERING, SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING, CORNELL UNIVERSITY

Prof. O'ROURKE. Thank you very much. Mr. Chair, and also Ranking Member Smith and Members of the Subcommittee, I am very happy to be here to testify today.

[Slide]

This first slide, by the way, illustrates Balboa Boulevard after the 1994 Northridge Earthquake in Los Angeles, and you'll see in this picture that ground failure here has ruptured high-pressure gas and water transmission pipelines, and those houses that you are looking at were literally burned from the top and flooded from the bottom. Twenty-five percent of the water supply was lost in Los Angeles as a consequence of that earthquake, and as you have mentioned before, there were billions of dollars of damage.

The National Earthquake Hazards Reduction Program is the backbone of U.S. seismic protection, and the risks are high. The risks are high because the population and assets in earthquake vulnerable areas are growing in the United States. NEHRP provides the support base for seismic monitoring, mapping, research, testing, code development, mitigation, emergency preparedness, but I think what is also equally important is that it served as an incubator for technology, for procedures and policy that go beyond earthquakes to reduce risk from all natural hazards and human threats. It has become a very important contributor to the technologies and the reduction of risks in all natural hazards.

The 2004 reauthorization of NEHRP called for a number of changes in the program. NIST is the lead agency, Interagency Coordinating Committee, Advisory Committee for Earthquake Hazards Reduction and Strategic Plan. All of these have really supported and enhanced the interagency coordination, and I am a member, as is Michael Lindell to my left, and Jim Harris—are members of the Advisory Committee for Earthquake Hazards Reduction. I think we all feel that the interagency coordination with the new reauthorization has really gone forward and is looking very good.

Support for NIST, which is the lead agency, because it is a lead agency. It is really in control and overseeing a vast portfolio, a large portfolio, of different programs, yet the support for NIST right now only accounts for about 1.4 percent of the enacted-year budget for fiscal year 2008. I think, and many other people do, too, that increased effort at NIST and additional support is a very important part of supporting the interagency coordination because as

lead agency, they need the support and the resources to be able to do their job effectively.

Engineering, research and development priorities include lifeline systems. These are the systems that really distinguish modern communities. They bring us energy, they bring us transportation, water supply, telecommunications, particularly looking at the interdependencies and the national impact, social and behavioral aspects of community response to earthquakes is actually important for engineering because actually the real infrastructure are the communities that the physical infrastructure serve. So getting the proper coordination there is important, performance-based seismic design, non-ductal concrete and other buildings with life safety threats.

There are also two important programs, one of them is the Advanced National Seismic System operated by the U.S. Geological Survey calling for 6,000 new stations to monitor strong motion, concentration in urban areas, and defining urban risks and then real-time shake maps.

The George A. Brown Jr., Network for Earthquake Engineering Simulation represents a tremendous opportunity for improving civil infrastructure, for being able to show new and emerging technologies and to be able to provide the evidence that is necessary for their implementation. With 15 sites across the United States, access worldwide, and by a whole number of different users, this is one of the gems of the earthquake program and certainly deserves support.

Technology transfer: NEHRP has been very effective in developing codes and standards, and FEMA has been the key agency for tech transfer and implementation. It is important to recognize that FEMA again has only been enacted for about 26 percent of its authorization, and so as the key agency for tech transfer implementation, we think that support should be increased so they could do their job more effectively. It is also, I think, important to revitalize the FEMA State earthquake programs and provide for mitigation fund. Supporting FEMA at authorized levels is the most effective way to promote technology transfer.

And then natural hazards R&D.

[Slide]

There has been a recent report by the Earthquake Engineering Research Institute which is shown here—I have copies for both Chair Wu and Mr. Smith—but this report documents the strong NEHRP as the best way to support natural hazards mitigation. There are many, many contributions from NEHRP to hazards mitigation which are listed here and explained in detail in the report.

And then finally, natural hazards R&D. One of the things to do to bring an R&D program for natural hazards that would include all hazards is to seek expert advice from the National Academies to the National Research Council [NRC]. This is a complex area with lots of different disciplines, and a study by the National Academies could be very effective in providing guidance on a good program.

Multi-hazards demonstration projects, some of them are being led by USGS in Southern California. A further development of those would be very useful, and then interaction between NEHRP

and the National Windstorm Impaction Reduction Program with NIST perhaps as the lead agency would be a good step toward being able to develop more coordination among the different hazards.

So the way forward is a strong NEHRP support, NEHRP support that is consistent with authorized levels, and that we think is the highest priority investment in disaster resilient communities. And then of course the improved hazards coordination through an NRC (National Research Council) study, multi-hazards demonstration projects, and interaction between earthquake and windstorm communities perhaps with NIST as the lead agency. Thank you very much.

[The prepared statement of Prof. O'Rourke follows:]

PREPARED STATEMENT OF THOMAS D. O'ROURKE

The National Earthquake Hazard Reduction Program (NEHRP) is the backbone for seismic protection in the United States. It provides federal support for research, information dissemination, development and implementation of technology, and the application of planning and management procedures to reduce seismic risk. It provides the resources and leadership for understanding and reducing U.S. vulnerability to earthquakes, and supplies the support base for seismic monitoring, mapping, research, testing, code development, mitigation and emergency preparedness. This support is critically important because the United States faces serious earthquake risk. This risk is growing because population density, property, and infrastructure are increasing in locations affected by earthquakes. The Federal Emergency Management Agency (FEMA) estimates that 45 states and territories are destined to experience earthquake damage. This exposure equals an annualized loss exceeding $6 billion dollars per year, with a single event loss potential of $100 to $200 billion dollars and tens of thousands of casualties. (FEMA, 2001, adjusted to 2009 dollars).

NEHRP is administered through four government agencies, with the National Institute of Standards and Technology (NIST) as the lead agency and the U.S. Geological Survey (USGS), National Science Foundation (NSF), and Federal Emergency Management Agency (FEMA) as the other partnering agencies. The USGS is the applied geosciences arm of NEHRP. It has successfully developed a procedure for translating Earth science into the information needed for seismic design. It reports on earthquakes worldwide, produces seismic hazard maps for use by design professionals, monitors for earthquake motions and effects, and helps develop public awareness, planning, and response preparations through coordination with the other NEHRP agencies and local communities. The NSF is the basic research arm of NEHRP, which supports research in engineering, Earth sciences, and the social sciences. It provides the engine that drives fundamental discoveries related to earthquake processes; seismic response and failure mechanisms of the ground, buildings, and lifeline networks; and human behavior, social response, and the economic conditions pertaining to earthquakes. FEMA is the primary implementation arm of NEHRP. It sponsors the development of guidelines and standards for the seismic evaluation and rehabilitation of existing buildings and for the design of new structures. It also provides technical and financial support to states, multi-State consortia, and individual communities to improve earthquake mitigation with grants to enhance public awareness, adopt earthquake resiliency measures, and support local projects. In addition to its role as lead agency, NIST supports the development of seismic codes and standards, and thus provides a critical link between the basic research supported by NSF and the implementation of that research, led largely through FEMA.

NEHRP is an incubator for technology and policy that extend well beyond seismic risk to improve the security and economic well-being of U.S. citizens through the reduction of risk from other hazards, such a floods, windstorms, hurricanes, and human threats. The contributions of NEHRP affect our lives through improvements in the perception, quantification, and communication of risk (EERI, 2008). They involve advanced technologies for strengthening the built environment, loss assessment methodologies, emergency response procedures, and a process for achieving disaster preparedness. They also involve a unique, multidisciplinary culture that integrates basic and applied research into design codes, construction methods, and public policy (EERI, 2008).

Not only does NEHRP protect lives and property from earthquake hazards, it contributes markedly to improvements in U.S. civil infrastructure. For example, research supported by NEHRP has substantially improved the modeling of complex lifeline systems, structural health monitoring, protective systems for buildings and bridges, and remote sensing for response and recovery from extreme events (EERI, 2008). Lifeline systems, including electric power, water supplies, gas and liquid fuel delivery, and telecommunications, are essential for the proper functioning and economic stability of modern communities. NEHRP sponsorship of lifelines research has led to break-through discoveries about the functionality and interdependence of critical infrastructure systems, and has stimulated interdisciplinary work among social scientists and engineers to quantify and reduce the community and economic impacts of lifeline losses after extreme events.

U.S. civil infrastructure is made all the more vulnerable to earthquakes and other natural hazards by its poor state of repair. Grades issued by the American Society of Civil Engineers (2009) are barely passing for every element of the built environment at a time when conditions have underscored the importance of infrastructure for a viable and competitive economy. NEHRP, through its basic research and implementation agencies at NSF, NIST, and FEMA, is ideally positioned to provide proof of concept for emerging technologies as well as the evidence needed to sustain their implementation. For example, the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) supported by NSF provides a national resource for demonstrating the cost-effectiveness of performance-based design, new materials to reduce the impact of earthquakes and other extreme events, and improved retrofit strategies that improve infrastructure performance on a daily basis as well as under conditions of unusual stress. The current reconstruction of the Nation's transportation networks has significantly benefited from NEHRP-sponsored research, including the USGS mapping program. The newest design guidelines and codes for bridge design include advanced seismic design and characterization provisions. Thus, the hundreds of billions of dollars our nation is investing in infrastructure reconstruction are better protected from significant earthquake effects because of the NEHRP program.

NEHRP distinguishes the U.S. as being at the forefront of globally important and life-saving technology. Our nation gains leverage from earthquake engineering research through worldwide improvements in safety, protection of life, and the exportation of our technology and engineering services overseas.

INTERAGENCY COORDINATION

There are several distinguishing features of the last NEHRP reauthorization (Public Law 108–360), including the establishment of NIST as Program Lead Agency, creation of the NEHRP Interagency Coordinating Committee (ICC), and appointment of an external committee of experts, known as the Advisory Committee on Earthquake Hazards Reduction (ACHER), to provide recommendations to the NEHRP agencies on implementing the program. The last NEHRP reauthorization also requires the preparation of a strategic plan by the ICC to guide and coordinate interagency activities within the program. All these aspects of NEHRP have been helpful in stimulating interagency coordination.

The establishment of the ICC has worked especially well. The ICC is composed of the Directors/Administrators of the four partner agencies plus the Directors of the Office of Science and Technology Policy and Management and Budget. The ICC met on numerous occasions since its inception in 2006. The meetings have been regularly attended by the National Science Advisor and prominent leaders of the other agencies, including the Directors of NSF and USGS. Such high level, active involvement has given NEHRP significant program visibility among agency leaders, which in turn has encouraged interagency coordination. Increased coordination has been achieved through ICC oversight of the NEHRP Strategic Plan, annual reports, and exchange of partnering agency budget preparation plans well in advance of the President's annual budget request.

NIST has provided focused and positive leadership for NEHRP. It has been active in developing a sound Strategic Plan, coordinating with the partnering agencies and the external earthquake community, and convening the ACEHR for guidance on the program.

Sixteen experienced earthquake professionals were first convened as members of the ACEHR in 2007. Biannual meetings of ACEHR have been held with representatives of the partnering agencies. The meetings have been held at the NIST headquarters in Gaithersburg, MD, and also at key locations around the U.S., such as the USGS National Earthquake Information Center in Golden, CO and the Pacific Earthquake Engineering Research Center at the University of California at Berkeley, CA. In addition, there have been several conference calls, in which the ACHER

members have exchanged views and made recommendations about program content. All meetings and conference calls have been open to the public. Frequent meetings and interchange with ACEHR have fostered interagency cooperation by providing a forum for collective agency reporting, collective dialogue with the external advisory committee, and the circulation of ACHER recommendations on NEHRP to all agencies. In its first annual report ACEHR (2008) observes that NEHRP "benefits from a high level of interagency coordination and a common focus." An excellent example of this collaboration is the NEHRP Strategic Plan for FY 2009–2013 (ICC, 2008). The plan outlines strategic priorities, each with a designated agency lead, and provides a template for coordinated and collaborative efforts among the NEHRP partner agencies.

A key opportunity to improve coordination is to increase the level of effort at NIST in NEHRP. The previous NEHRP reauthorization envisioned leadership at NIST that would grow from 2004 to 2009 with increasing levels of funding authorized to support expanding managerial and technical activities. This makes sense. As lead agency, NIST has stewardship for the entire program and requires a level of support commensurate with oversight of the sizable NEHRP portfolio of projects and activities. As of FY 2008, NEHRP support enacted for NIST was only 1.4 percent of the enacted budget.

As discussed previously, NIST plays a pivotal and integrating role in NEHRP by acting as the vehicle for channeling basic research from NSF projects to implementation with the assistance of FEMA. Enabling this role with the support that was envisioned in the last NEHRP reauthorization would help greatly to foster increased coordination by tying together more effectively the programs at NSF, FEMA, and USGS. The funds enacted for NIST account for only 12.8 percent of its support authorized for FY 2008. This is too low, and presents an opportunity to increase the productivity of NEHRP. Increasing support for NIST to be consistent with current authorized levels is perhaps the most effective way to improve interagency coordination as well as increase the overall effectiveness of NEHRP.

Enhanced interagency coordination and support is needed for earthquake reconnaissance. Because earthquake occurrences are rare, it is imperative to invest substantial resources in learning from them. Reconnaissance of an earthquake affected area within a short time after the event will capture unique, time-sensitive and perishable data of great value for improved understanding of earthquake effects and a real-world test bed for existing models. There should be coordinated support for earthquake reconnaissance activities from all NEHRP agencies.

Recommendations by ACEHR (2008) call for a transfer of leadership from USGS to NIST for coordinating post-earthquake reconnaissance efforts. ACEHR recommends that "NIST should serve as the single point of coordination, without any discipline-specific individual responsibility, to ensure that all key aspects of an event are captured in a balanced manner." This change is recommended for incorporation in the current reauthorization cycle.

Preparing for earthquake reconnaissance and coordinating missions is time-intensive and demanding work. Adequate staff and funding are required for successful reconnaissance, thus emphasizing further the need for additional resources to NIST to fulfill its NEHRP leadership role.

Care and coordination needs to be exercised in the collection and archiving of data from earthquake reconnaissance. ACEHR (2008) recommends archiving reconnaissance data in a Post-Earthquake Information Management System (which is introduced in the new Strategic Plan), where data would be available in a set of discipline oriented interactive media with information related to the short- and long-term effects of earthquakes.

PRIORITIES FOR EARTHQUAKE ENGINEERING R&D

Earthquake engineering R&D must be judged in context of the earth science quantification of design hazards and the societal impact associated with the engineering and construction that are proposed for the real world. Hence, a robust engineering R&D program must be integrated with strong earth and social science R&D activities.

USGS is building the Advanced National Seismic System (ANSS) that will modernize and expand the earthquake monitoring system in the U.S., with concentrations in urban environments and the collection of data pertaining to actual building response. If we are to arrest the growth of earthquake risk in the United States, the USGS must enhance our understanding of earthquake ground motion throughout the country so we can identify areas that need concentrated mitigation activities, recognize those areas where conservatism can be reduced (thus realizing considerable savings), and refine our modeling and design procedures for seismic soil-structure interaction. This problem is so large and expensive that we cannot afford

to rely solely on the current information to guide our engineering approaches and policy decisions. The ANSS is currently deployed at about 15 percent of its planned capacity. The deployment of ANSS needs to be accelerated with a strong commitment to achieving the completion of this program in a timely manner.

NSF is operating the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), which consists of state-of-the-art experimental facilities distributed across the U.S. working in unison through advanced telecommunications and high performance Internet. The network is focused on the large-scale behavior of critical facilities under complex earthquake loadings and the validation of analytical and computer models needed for effective engineering. NEES links sites throughout the U.S. and globally to create a shared resource that benefits from open access and the contributions of leading researchers at multiple locations. If we are to arrest the growth of earthquake risk in the U.S., we must discover how large-scale structures and lifelines actually respond to earthquake effects and develop more cost efficient methods for reducing their vulnerabilities to acceptable levels. NEES is critically important for accomplishing this. As discussed previously, NEES is a national resource for advancing technologies to improve U.S. infrastructure. Recent ACEHR (2008) recommendations include developing support from other federal agencies to leverage NSF investments in NEES.

The resilience of communities and the built environment are interrelated, and thus research into the social and behavioral aspects of community response to earthquakes is a natural complement to research that increases the resiliency of the built environment. The National Research Council report, *Facing Hazards and Disasters: Understanding Human Dimensions* (National Research Council, 2006) identifies a number of research priorities, including the effects of changes over time in hazard-related laws, policies, and programs; human dynamics and incentives for adopting mitigation measures; and the challenges of catastrophic events. The most recent ACEHR report (2008) calls attention to this report and encourages an integrative R&D effort into the political, social, and economic circumstances that motivate society to achieve community resilience to earthquakes.

As discussed previously, lifeline systems are critically important parts of the built environment. They deliver the resources and services necessary for the health, economic well-being, and security of modern communities, which are susceptible to malfunctioning under the effects of severe hazards, such as earthquakes. Thus, a strong R&D effort focused on lifeline systems is important for NEHRP. Research and development in lifeline earthquake engineering was supported within NEHRP by FEMA under the American Lifelines Alliance. Unfortunately, this program was discontinued in 2007 with no replacement. Future R&D within NEHRP should place more emphasis on lifelines. To accomplish this, it would be appropriate to ask NIST, the lead agency, to convene a workshop of experts from academia, public and private utility companies, practicing engineers, social scientists, and economists to advise the NEHRP partner agencies on the most promising areas of R&D and the most effective process for achieving and implementing the needed research. Greater emphasis on lifelines is recommended by ACEHR (2008), which points out that there has not been sufficient attention given to the interdependencies among lifeline systems or the national impact that a single outage can have. ACEHR recommends that all NEHRP agencies expand their activities related to lifeline systems.

R&D support should be increased for Performance-Based Seismic Design (PBSD). A recent report by NIST (2009) provides a blueprint for the needed research. PBSD is a process that supports the design of new buildings or upgrades to existing buildings, with a realistic understanding of the risk of life, occupancy, and economic losses that may occur as a result of future earthquakes. The design of the building is adjusted so that the projected risks of loss are deemed acceptable, given the cost of achieving the intended level of performance. With PBSD, buildings are designed with an explicit understanding of the risk of loss (physical, direct economic, and indirect economic). The PBSD concepts can be applied readily to other hazards, such as wind, flood, and blast effects.

A serious life safety threat exists with respect to non-ductile concrete, soft story, and unreinforced masonry buildings. A non-ductile concrete building is one that does not contain sufficient reinforcing steel to accommodate deformation during earthquake shaking with the result that failure of concrete structural members can occur catastrophically with loss of life. Catastrophic failure can also occur in buildings with soft stories, unable to accommodate the transient distortion imposed by earthquake motion, and in unreinforced masonry buildings. Additional work is needed to identify and either remove or retrofit such buildings. Thousands of non-ductile concrete structures exist in various parts of the U.S. with more than 2000 in southern California alone. Research is needed both to identify such structures and to develop cost-effective methods to rehabilitate them.

A research and outreach plan was developed by the Earthquake Engineering Research Institute (EERI, 2003), called *Securing Society Against Catastrophic Earthquake Losses.* The plan was developed by a broad and multi-disciplinary cross-section of experts. It includes both practical and basic research, and contains an outreach component that addresses implementation, education, and technology transfer. The plan calls for a five-fold program, consisting of research and development pertaining to Understanding Seismic Hazards, Assessing Earthquake Impacts, Reducing Earthquake Impacts, Enhancing Community Resilience, and Expanding Education and Public Outreach. Detailed descriptions of topics and work are provided in the document for each program area, with a recommended level of funding of $330 million per year to achieve national resiliency against earthquakes within a 20-year time frame. Enacted NEHRP funding for FY 2006 through 2008 has averaged $119.5 million, which is only 64 percent of the FY 2008 authorized level.

TECHNOLOGY TRANSFER

A major component of technology transfer in earthquake engineering is the promulgation of codes and standards. Much has been accomplished by the earthquake engineering community under NEHRP with respect to the development of codes and standards, including methods for predicting earthquake damage, evaluating the seismic capacity of existing buildings, rehabilitating buildings to improve their seismic resistance, and evaluating and repairing earthquake-damaged buildings. The bridge community has developed seismic design specifications through the American Association of State Highway and Transportation Officials. Earthquake-resistant design procedures have been incorporated into the *International Building Code* (ICC, 2006), which is promulgated by one recognized building code authority, and into the standard, *Minimum Design Loads for Buildings and Other Structures,* issued by the American Society of Civil Engineers (ASCE, 2006).

As previously discussed, FEMA is the NEHRP agency with primary responsibility for implementation. Its roles include sponsorship of guidelines and standards for the design of new structures and for the seismic evaluation and rehabilitation of existing buildings, as well as the support of states, multi-state consortia, and individual communities to improve earthquake mitigation. It is a critically important agency for technology transfer.

Until 2001, FEMA had a dedicated program to provide assistance to states with high earthquake risks through direct support to their State earthquake program managers. Since 2003, that assistance has been subsumed into other State and local Department of Homeland Security grant programs. The net effect has been to reduce markedly the overall preparedness of many of the State earthquake programs as well as the visibility and effectiveness of the earthquake managers of those State programs. Numerous State earthquake program managers have lost there identity and very few can gain access to the resources they previously received. It is important now to re-establish support for the State programs so they can be ready to respond in a future earthquake. There are indications that this is beginning to occur in 2009, which is a promising development that needs encouragement and continued support.

In FY 2008 NEHRP funds enacted for FEMA were only 26 percent of their authorized level. ACEHR (2008) recommends revitalizing the State earthquake programs and support for pilot studies to mitigate earthquake risk in communities. In addition to the continued development of guideline documents for code preparation and practice, ACEHR further recommends funding for FEMA at authorized levels. Additional support for FEMA and restoration of the State programs is the most effective way to promote technology transfer and assure support dedicated to risk reduction.

RESEARCH AND DEVELOPMENT FOR NATURAL HAZARDS

One of the best ways to support natural hazards mitigation is to support a strong and effective NEHRP. Investments in earthquake engineering through NEHRP make a significant impact on life safety and the protection of property from all kinds of natural hazards such as wildfires, flood, wind, and hurricanes, and from human threats such terrorism and severe accidents. The Earthquake Engineering Research Institute (2008) has produced a report, *Contributions of Earthquake Engineering to Protecting Communities and Critical Infrastructure from Multi-hazards,* which documents the ways by which NEHRP has been the incubator for new ideas, advanced technologies, emergency management practices, and public policy affecting multi-hazard reduction and improvements in critical civil infrastructure. The report was assembled with input from a multi-disciplinary team of experts, representing practicing engineers, geoscientists, applied social scientists, and academic researchers.

The contributions of NEHRP are legion, and have had a substantial impact on public perception and assessment of seismic risk, advanced technologies for reinforcing and monitoring the built environment, loss assessment methodologies, emergency preparedness and response procedures, and a culture for integrating basic and applied research into design codes, construction methods, and public policy. Among the notable achievements of NEHRP with significant impact outside earthquake engineering are the modeling methods for probabilistic seismic hazard assessment, which are used worldwide by the insurance industry to distribute risk associated with all types of natural hazards. NEHRP is responsible for advanced remote sensing technologies, initially developed for post-earthquake reconnaissance, but also applied to damage assessment and recovery after hurricanes, such as Hurricanes Katrina and Rita. Other examples include methodologies for modeling and managing interdependent lifeline systems, active and passive control systems to protect buildings and bridges during transient loading, seismological contributions to nuclear test and explosion monitoring, developments in the Incident Command System for multi-agency response to earthquakes and other natural disasters and human threats, and post-earthquake building inspection protocols that were adapted to evaluate New York City buildings after the World Trade Center Disaster.

NEHRP has been a cornerstone program for technologies and methodologies applied to natural hazards. At the same time, it has generated a culture of multi-disciplinary innovation through the collective enterprise of architects, emergency managers, engineers, geoscientists, and social scientists. The multi-disciplinary character of NEHRP is one of its most enduring legacies, providing a model for future mitigation of natural hazards and human threats.

As pointed out by EERI (2008), the reauthorization of the *Earthquake Hazards Reduction Act* in 2004 was used as the legislative vehicle for introducing and passing the *National Windstorm Impact Reduction Act of 2004*. The multi-agency oversight of NEHRP was used as the model for the National Windstorm Impact Reduction Program (NWIRP). Both programs are administered with the assistance of a federal interagency committee for coordination and an external national advisory group that provides guidance and recommendations for program activities.

Designating NIST as the lead agency for NWIRP would provide NIST with oversight of both NEHRP and NWIRP. Common leadership would provide an opportunity to promote dialogue and coordination between the earthquake and windstorm research communities. There should be separate funding sources for NEHRP and NWIRP. Strong and secure funding for NEHRP is needed to build on the foundation of a successful, multi-disciplinary earthquake program to support multi-hazard R&D.

Coordinated hazards R&D is being promoted through USGS with a Multi-hazard Demonstration Project in Southern California (USGS California Water Science Center, 2009). The objective of this project is to increase resiliency to natural hazards by using southern California as a testbed. Partners include State, county, and city governments, public and private utilities, private businesses, academic researchers, emergency response agencies, and representatives of USGS, FEMA, and NOAA. The hazards involved in the project are earthquakes, floods, wildfires, landslides, coastal erosion, and tsunamis. Similar projects in other locations would help develop better coordination of hazards R&D across the Federal Government.

Coordinated hazards research involves diverse research communities and constituencies associated with earthquakes, windstorms, floods, coastal hazards, wildfires, etc. Each hazard involves scientific causes, modeling processes, and engineering practices that differ from those related to the other hazards. Coordinating hazards research must accommodate different institutional cultures and stakeholders as well as a multitude of different government agencies, all of which need to be carefully integrated in an effective collaboration. Given the complexity of this undertaking, expert advice should be sought from the National Academies through the National Research Council (NRC). A comprehensive, multidisciplinary study by the NRC should be convened to explore the barriers, opportunities, and most promising strategies for coordinated hazards research within the Federal Government.

CONCLUDING REMARKS

The National Earthquake Hazard Reduction Program (NEHRP) provides the underpinning for the resilience of U.S. communities to earthquakes. It provides federal support for research, information dissemination, development and implementation of technology, and the application of planning and management procedures to reduce seismic risk. This support is critically important because the United States faces serious earthquake risk. NEHRP also serves as an incubator for technology, practices, and policy for the reduction of risk from other hazards, such a floods, windstorms, hurricanes, and human threats. A strong NEHRP not only protects

U.S. citizens from seismic hazards, but provides a cornerstone program for the multi-hazard resilience of U.S. communities.

The most recent reauthorization of NEHRP has brought about changes that have been effective in promoting interagency coordination as well as a more integrated and cohesive program. An excellent example of interagency collaboration is the NEHRP Strategic Plan for FY 2009–2013, which outlines strategic priorities, and provides a template for coordinated and collaborative efforts among the NEHRP agencies. One of the best ways to promote interagency coordination is to increase support for NIST to be consistent with current authorized levels. NIST plays a pivotal and integrating role in NEHRP, and enabling this role with the support envisioned in the last NEHRP reauthorization would help greatly to foster increased coordination and effectiveness of the program.

Priorities for earthquake engineering R&D include enhanced support for ANSS and NEES. They include a strong and collaborative research effort on lifeline systems, with emphasis on the interdependencies of critical infrastructure and the national impact of critical lifeline losses on regional and national economies. Priorities involve research on the social and behavioral aspects of community response to earthquakes and other natural hazards, and the interaction of social and political factors with engineering design and construction. R&D emphasis should be given to Performance Based Seismic Design and the identification and development of cost-effective retrofitting technologies for non-ductile concrete and other life-threatening buildings.

To promote technology transfer and implementation of research findings in U.S. communities, it is vitally important to increase support for FEMA. There has been serious erosion in FEMA's dedicated program to provide assistance to states with high earthquake risks through direct support to their State earthquake program managers. The FEMA State earthquake programs and community pilot studies to mitigate earthquake risk should be re-vitalized during this reauthorization.

Of critical importance is the enactment of support for NEHRP that was envisioned in the last reauthorization. As expressed in the first annual report of the Advisory Committee for Earthquake Hazards Reduction (ACEHR), there is concern for the withering of enacted funds. Funding for the program has either been flat or below inflation levels for the last 30 years. Many effective NEHRP projects important for life safety and community resilience have been successfully undertaken within the limits of the enacted budgets. These successes show the potential for greater impact and effectiveness if the authorized levels of support can be realized. Support consistent with authorized levels represents the highest priority investment in developing disaster-resilient communities.

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BIOGRAPHY FOR THOMAS D. O'ROURKE

Professor O'Rourke is the Thomas R. Briggs Professor of Engineering in the School of Civil and Environmental Engineering at Cornell University. He is a member of the U.S. National Academy of Engineering and a Fellow of American Association for the Advancement of Science. He has received several awards from professional societies, including the Collingwood, Huber Research, C. Martin Duke Lifeline Earthquake Engineering, Stephen D. Bechtel Pipeline Engineering, and Ralph B. Peck Awards from American Society of Civil Engineers (ASCE), Hogentogler Award from American Society for Testing and Materials, Rankine Lecture sponsored by the British Geotechnical Association, Trevithick Prize from the British Institution of Civil Engineers, and Japan Gas and Earthquake Engineering Research Institute (EERI) Awards for outstanding papers. He served as President of EERI, as a member of the National Academies Committee for New Orleans Regional Hurricane Protection Projects, and currently as a member of both the Advisory Committee for Earthquake Hazards Reduction, which provides oversight advice the National Earthquake Hazards Reduction Program, and the National Academies Board on Water Science and Technology. He has authored or co-authored over 340 technical publications. He has served as Chair or member of the consulting boards of many large underground construction projects, as well as the peer reviews for projects associated with highway, rapid transit, water supply, and energy distribution systems. He has been involved in numerous earthquake reconnaissance missions. His research interests cover geotechnical engineering, earthquake engineering, underground construction technologies, engineering for large, geographically distributed systems, and geographic information technologies and database management.

Chair WU. Thank you very much, Professor O'Rourke. Dr. Lindell, please proceed.

STATEMENT OF DR. MICHAEL K. LINDELL, PROFESSOR, LANDSCAPE ARCHITECTURE AND URBAN PLANNING; SENIOR SCHOLAR, HAZARD REDUCTION & RECOVERY CENTER, TEXAS A&M UNIVERSITY

Dr. LINDELL. Good morning. My remarks today in support of the NEHRP reauthorization will be based substantially on recommendations of the National Science Foundation's Second Assessment of Research on Natural Hazards and the National Academy of Sciences Committee on Disaster Research in the Social Sciences.

I would like to address the first question, what is the role of social science research in making communities hazard resilient, by noting that one of the Second Assessment committees concluded that households and businesses typically are unaware of the risks they face, underestimate the risks of which they are aware, and overestimate their ability to cope when disaster strikes. These limitations lead them to encroach into high hazard areas, underutilize pre-impact hazard mitigation and preparedness and rely too much on post-impact emergency response and disaster relief.

Thus, the role of social scientists is to better understand the psychological, social, economic, and political causes of community haz-

ard vulnerability. Second, we want to scientifically test possible ways to increase hazard resilience. Third, we seek to work with other disciplines to disseminate administrative as well as technological innovations that increase community hazard resilience.

Regarding the second question, how has social science been integrated into NEHRP activity and other federal hazards R&D, I want to say that the cornerstone of NEHRP support for social science hazards research over the past decades has been the NSF's Engineering Directorate, either alone or in collaboration with its Social, Behavioral, and Economic Sciences Directorate. In addition, USGS and FEMA have supported research and dissemination of social science findings.

Regarding the third question, what are the priorities for social science for a reauthorization of NEHRP and other federal hazards R&D programs, I want to discuss priorities in three areas, hazard and vulnerability analysis, pre-impact actions, and post-impact actions.

Regarding hazard vulnerability analysis, the major social science question is which population segments and economic sectors are most vulnerable to disasters, what are their points of vulnerability, and what can government and non-governmental organizations do to reduce this vulnerability? We have already identified vulnerable population segments, but we need to learn more about the specific difficulties they have in hazard mitigation, emergency preparedness, disaster recovery, and insurance purchase. Similarly, we need to know more about businesses and how their vulnerability varies by economic sector and what specific difficulties they experience. Addressing these questions through longitudinal studies that track households and businesses over time will tell us how government and non-governmental organizations can more effectively provide assistance.

With regard to pre-impact actions, we know that households and businesses are not taking adequate levels of pre-impact action, and we have some explanations for why this is so. In some cases the solution is to invest in risk communication programs, but we still have much to learn about how to persuade people to prepare for low-probability, high-impact events such as earthquakes. In addition, research is needed to determine how to design extrinsic inducement programs—incentives and sanctions—so they provide the greatest increase in community resilience for the minimum cost to government and non-governmental organizations. In particular, we need large-scale, coordinated field experiments that involve collaboration between communities that are willing to adopt innovative programs and social scientists who will evaluate these programs.

With regard to post-impact actions, this country made a major commitment after 9/11 to implement the Incident Command System [ICS]. ICS is a major improvement over the multiplicity of idiosyncratic systems that it is displacing, but it deserves systematic evaluation to assess its limitations and identify improvements. In the more than 30 years since its inception, there have only been a handful of empirical studies on its effectiveness; a program that the Federal Government mandates for local governments to qualify for disaster reimbursement should be examined more thoroughly than that.

We know that communities recover more rapidly if they engage in pre-impact recovery planning, but most wait until after disaster strikes to plan for the recovery. As a consequence, recovery is slow, stakeholders are frustrated, and hazard mitigation is poorly integrated into the recovery process. Thus, systematic social science is needed in this area also.

Finally, I strongly endorse efforts to promote a multi-hazard approach to increasing community resilience. Over the past 30 years, I have done research in floods, volcanic eruptions, volcanic hazards at fixed-site facilities and transportation, toxic chemical facilities, earthquakes, hurricanes, and tsunamis. Although there are findings that are specific to each of these hazards, there are many commonalities that would provide multi-hazard research with an opportunity to achieve extremely beneficial outcomes that would reinforce the findings in different hazards. Thank you.

[The prepared statement of Dr. Lindell follows:]

PREPARED STATEMENT OF MICHAEL K. LINDELL

Good morning. My name is Dr. Michael K. Lindell; I am a Professor at Texas A&M University and conduct emergency management research in the Hazard Reduction & Recovery Center. I want to thank you for the opportunity to speak on behalf of the many social scientists who are conducting research supported by NEHRP agencies. My remarks today will be based substantially on the analyses and recommendations of the National Science Foundation's *Second Assessment of Research on Natural Hazards* and the National Academy of Sciences *Committee on Disaster Research in the Social Sciences* (see Attachments 1 and 2).

1. What is the role of social science research in making communities hazard resilient?

One of the committee reports from the NSF's *Second Assessment* concluded that households and businesses typically are unaware of the risks they face, underestimate the risks of which they are aware, and overestimate their ability to cope when disaster strikes. In addition, they have competing demands for their attention, short planning horizons, bounded rationality, and limited economic resources. These limitations increase communities' hazard vulnerability because they lead households and businesses to encroach into high hazard areas, underutilize pre-impact hazard mitigation and preparedness, and rely too much on post-impact emergency response and disaster relief.

Thus, the role of social scientists is threefold. First, we seek to better understand the psychological, social, economic, and political causes of community hazard vulnerability. Second, we want to scientifically test possible ways to increase hazard resilience. Third, we seek opportunities to work with emergency managers, architects, engineers, planners, and public administrators to disseminate administrative and technological innovations that increase community hazard resilience.

2. How has social science been integrated into NEHRP activity and other federal hazards R&D?

The cornerstone of NEHRP support for social science hazards research has been NSF's Engineering Directorate either alone or in collaboration with its Social, Behavioral, and Economic Sciences Directorate. NSF has primarily supported unsolicited proposals submitted by individual investigators and solicitations in response to domestic and international disasters. In addition, USGS has supported social science evaluations of some of its hazard awareness programs (Mileti & Darlington, 1995; Mileti & Fitzpatrick, 1993; Perry, 1990; Perry & Lindell, 2008) and FEMA has supported dissemination of social science research findings through its *Higher Education Initiative* (*training.fema.gov/EMIWeb/edu/*). Most of the social science projects funded by federal research programs have involved investigators from a single discipline. However, there have also been projects involving collaboration among multiple social science disciplines and, sometimes, social scientists collaborating with engineers and physical scientists. There have also been a few interdisciplinary efforts such as NSF's *Human and Social Dynamics Program* and its *Earthquake Engineering Research Centers*. As yet, these efforts are only beginning to develop the

kinds of interdisciplinary cooperation that is needed to increase community hazard resilience.

3. What are the priorities for social science for a reauthorization of NEHRP and other federal hazards R&D programs?

I will discuss priorities in three major areas—hazard and vulnerability analysis, pre-impact actions (hazard mitigation and disaster preparedness) and post-impact actions (emergency response and disaster recovery). I will conclude with a discussion of the utility of an all-hazards approach in social science research.

Hazard/vulnerability analysis

Although it is something of an oversimplification, we can say that physical scientists identify which geographic areas are exposed to hazards and engineers address which structures are most likely to fail. The corresponding social science question is "Which population segments and economic sectors are most vulnerable to disasters, what are their points of vulnerability, and what can government and nongovernmental organizations (NGOs) do to reduce this vulnerability?" Of course, we know that ethnic minorities, female-headed households, poorly educated, low income, physically or mentally disabled, and socially isolated citizens are disadvantaged—even under the best of circumstances. Thus, we expect them to be most vulnerable to disasters (e.g., Bolin & Stanford, 1998; Peacock, Morrow & Gladwin, 1997). However, we need to learn more about the *specific* difficulties they have in hazard mitigation, emergency preparedness, and insurance purchase. We also know in broad terms that small businesses are more vulnerable to disasters. However, we need to know more about how businesses' vulnerability varies by economic sector and what specific difficulties they experience (Alesch, Taylor, Ghanty, & Nagy, 1993; Webb, Tierney & Dahlhamer, 2000). For both households and businesses, we need to know more about how government and NGOs can more effectively provide assistance. Answering these questions will require longitudinal studies that track households and businesses over extended periods of time.

Pre-impact actions

In general terms, we already know what needs to be done to make communities more disaster resilient. At the household level, pre-impact actions include hazard mitigation (bolting structures to their foundations and strapping water heaters to walls) and disaster preparedness (storing food and water, purchasing first aid kits and learning how to treat minor injuries, and purchasing hazard insurance). For emergency response organizations, pre-impact actions include developing plans, acquiring resources, and conducting training and exercises to support emergency response—as well as engaging in mitigation actions to ensure their buildings and material resources survive a disaster. At the community level, pre-impact actions include land use plans that discourage intensive development of high hazard areas and prohibit the siting of highly vulnerable facilities such as hospitals, nursing homes, and schools in high hazard areas. They also include programs such as building codes and standards to increase buildings' elevation (for flooding) and structural resilience (for wind and earthquakes) if they are built in high hazard areas.

At all levels—households, businesses, and communities—we know that the level of pre-impact action is inadequate. Social scientists have published many small-scale studies that suggest why this is so (Lindell, Arlikatti & Prater, in press; Lindell & Perry, 2000). We know that people *will* voluntarily adopt hazard adjustments that are high in efficacy—ones that protect persons and property and are useful for other purposes. We also know that they will *not* voluntarily adopt hazard adjustments that are high in resource requirements—ones that are expensive, or require substantial time and effort, specialized knowledge and skill, specialized tools and equipment, or substantial amounts of cooperation with others. A major obstacle to improving community hazard resilience is that some of the most promising hazard adjustments—hazard insurance for example—have very low rates of adoption. In some cases, the problem is that people have erroneous beliefs about these hazard adjustments. That is, people underestimate efficacy or overestimate resource requirements. Worse yet, people often don't know about the existence of many of the hazard adjustments that are available. In such cases, the level of hazard adjustment adoption might be increased by investing in risk communication programs. Although we know much more about risk communication than we did thirty years ago, we still have much to learn about how to persuade people to prepare for low-probability events such as earthquakes (Lindell & Perry, 2004). Especially when people fail to adopt hazard adjustments because the personal cost of a hazard adjustment exceeds the short-term personal benefits, extrinsic inducement programs—incentives and

sanctions—may be needed. However, research is needed to determine how to design these inducements so they provide the greatest increase in community resilience for the minimum cost to government and NGOs.

Current research provides an adequate base of small-scale studies for designing comprehensive research on the effects of incentives, sanctions, and risk communication. What we most need to do next is to conduct *large-scale coordinated field experiments*. We know that there are many communities that are willing to undertake—and in many cases have actually implemented—innovative programs to promote hazard resilience. Unfortunately, only a few of these programs are documented and fewer still have been scientifically evaluated. This is a major disappointment because every one of these situations represents a squandered opportunity to learn from experience. As noted earlier, USGS has supported some small studies that begin to address this issue. However, we can do much more if NEHRP will support collaboration between communities that are willing to adopt innovative programs and social scientists who will collect and analyze data from these programs to evaluate their effectiveness.

Post-impact actions

Although household actions are important, some of the most important emergency response and disaster recovery actions are taken by community organizations. Coordination has repeatedly been identified as a major problem in emergency response and the challenges seems to increase with the magnitude of the disaster. This country made a major commitment after 9/11 to adopting the Incident Command System (ICS) as a mechanism for coordinating disaster response. ICS is a major improvement over the multiplicity of idiosyncratic systems that it is displacing, but it deserves systematic evaluation to assess its limitations and identify improvements. In the more than thirty years since its inception, there have been only a handful of empirical studies on ICS effectiveness (see Lutz & Lindell, 2008). A program that the Federal Government mandates for local governments to qualify for disaster reimbursement should be examined more thoroughly than that.

We have textbooks (Phillips, 2009) and planning guidance (Natural Hazards Center, 2001; Schwab, Topping, Eadie, Deyle & Smith, 1998) that identify problems and recommend solutions for a timely and effective disaster recovery. There is evidence that communities recover more rapidly if they engage in *pre-impact* recovery planning (Wu & Lindell, 2004) but most communities wait until after a disaster strikes to plan their recovery. As a consequence, the pace of recovery is slow, stakeholders (especially vulnerable populations) are frustrated, and hazard mitigation is poorly integrated into disaster recovery plans, causing communities to recreate their pre-existing hazard vulnerability. Thus, systematic social science research is needed on communities of different sizes and different economic bases to determine what can be done to improve post-disaster recovery planning. This will help all population segments and economic sectors recover more rapidly and completely and reduce the problem of repetitive losses.

All-hazards social science research

Finally, I would like to conclude by presenting some reasons why NEHRP agencies should support social science research on a variety of hazards. A basic premise for hazards researchers is that we have limited opportunities to study earthquake emergency response and recovery in the U.S. because major earthquakes are, thankfully, rare. We can learn much by studying societal response to earthquakes in other countries and numerous Earthquake Engineering Research Institute studies have done so. However, we also need to take advantage of the lessons that can be learned from studying other, more frequent, hazards in this country. Indeed, most environmental hazards are relevant and there are two reasons why this is so. First, earthquakes can themselves generate secondary threats—including tsunami, landslides, dam failures, urban conflagrations, and hazardous materials releases. In fact, earthquakes and their secondary hazards cover most of the spectrum of disaster impacts to which the U.S. is vulnerable.

Second, there appear to be significant similarities in societal responses to different hazards. Specifically, even though a hazard agent might be caused by physical mechanisms that are quite different from those that cause earthquakes, the two hazards can still have critical *impact characteristics* in common (see Lindell, Prater & Perry, 2006, for further discussion of cross-hazard similarities). For example, tornadoes are generated by quite different physical systems than are earthquakes. However, both are rapid onset disasters that provide minimal or no warning. The similarity in the impact characteristics of the two events produces similar societal responses. As a consequence of this principle, hazard mitigation functions (such as

land use planning and building codes) and emergency preparedness functions (such as planning, training, and exercising) are similar for most environmental hazards. The same is true for disaster recovery functions such as debris removal, donations management, temporary housing. Even the needs for emergency response functions such as search and rescue, emergency sheltering, interagency coordination, and emergency public information are similar across disasters. It is true that there are some emergency response functions such as pre-impact warning and evacuation that are not possible with current earthquake detection technology. However, earthquakes' secondary hazards such as dam failures and tsunami can be detected far enough in advance to support even these functions. Consequently, what social scientists can learn from mitigation, preparedness, response, and recovery associated with seemingly dissimilar hazards—such as hurricanes, floods, and tornadoes—can be effectively applied to reducing community vulnerability to earthquakes.

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Attachment 1

Committee on Disaster Research in the Social Sciences
Summary of the Current State of Social Science Research

The [Committee on Disaster Research in the Social Sciences] assessment of the current state of social science research is based on a detailed review of scientific literature in the field. The report's authoring committee also benefited from presentations and discussions that took place during two workshops held in conjunction with committee meetings, one in Washington, DC and the other in Irvine, California. Participants in the first workshop included researchers from the multi-disciplinary hazards and disaster research community, practitioners, and representatives from various agencies. All participants in the second workshop were practitioners. Based on this input, the report draws the following conclusions about the current state of social science research:

1. Social science hazards and disaster research has advanced in the United States and internationally.

Under NEHRP social science knowledge has expanded greatly with respect to exposure and vulnerability (physical and social) to natural hazards in the United States, such that the foundation has been established for developing more precise loss estimation models and related decision support tools for hazards and disasters generally. The contribution of NEHRP to social science knowledge on natural hazards is less developed internationally as is its contribution nationally and internationally on exposure and vulnerability to technological and willful threats.

2. Social science knowledge about the responses of U.S. households to natural hazards and disasters is well-developed.

There is a solid knowledge base at the household level of analysis on vulnerability assessment, risk communication, evacuation and other forms of protective action, and expedient disaster mitigation activities—for example, how people in earthquake or flood prone regions communicate about risks and warning messages, and how they respond to warning messages. The knowledge base and related explanatory modeling under NEHRP are skewed toward natural hazards (most notably earthquakes) as opposed to technological and willful hazards, and so far they have been confined primarily to national rather than international contexts.

3. Far less is known about how the characteristics of different types of hazards affect disaster preparedness and response.

There has been little systematic comparative work on the special characteristics of natural, technological, and willful disasters (e.g., predictability and controllability; length of forewarning, magnitude, scope, and duration of impact) and their relationships with physical and social impacts. For example, how does the variation in warning time—little or no warning for an earthquake, short-term warning for tornadoes, longer-term warnings for hurricanes, and indeterminate warnings for terrorist attacks—affect preparedness and response? Greater understanding of event/impact relationships would directly facilitate the adoption of more effective disaster preparedness and mitigation practices.

4. More is known about immediate post-disaster responses of groups, organizations, and social networks than about mitigation or disaster recovery policies and practices.

While less so than the post-World War II studies that preceded NEHRP's establishment in 1977, NEHRP-sponsored social science research has still tended to focus more on the immediate aftermath of disasters (post-disaster responses) and related emergency preparedness practices than on the affects of pre-disaster mitigation policies and practices, disaster recovery preparedness or longer term recovery from specific events. Research over several decades has contradicted myths that during disasters panic will be widespread, that large percentages of those who are expected to respond will simply abandon disaster roles, that local institutions will break down, that crime and other forms of anti-social behavior will be rampant, and that psychological impairment of victims and first responders will be a major problem. The more interesting and important research questions have become how and why communities, regions, and societies leverage expected and improvised post-impact responses in coping with the circumstances of disasters. While much of organizational response to disaster is expected and sometimes planned, improvisation is an absolutely essential complement of predetermined activities.

5. The circumstances of terrorist threats could alter societal response to disasters.

The possibility exists that some future homeland security emergencies could engender responses that are different from those observed in previous post-disaster investigations of natural and technological disasters. Particular attention is being given post-September 11, 2001 to vulnerability assessment of national energy, transportation, and information systems, terrorist threat detection and interdiction, the special requirements of nuclear, biological, and chemical agents, and the organizational requirements of developing multi-governmental preparedness and response systems. Fortunately these concerns are readily subsumed within the historically mainstream topics of hazards and disaster research depicted in Figure 1 above.

6. NEHRP has made important contributions to understanding longer-term disaster recovery.

Prior to NEHRP relatively little was known about disaster recovery processes and outcomes at different levels of analysis (e.g., households, neighborhoods, firms, communities, and regions). While research on disaster recovery remains somewhat underdeveloped, NEHRP funded projects have refined general conceptions of disaster recovery, made important contributions in understanding the recovery of households (primarily) and firms (more recently), and contributed to the development of statistically based community and regional models of post-disaster losses and recovery processes. Moreover, interest in the relationship between disaster recovery and sustainable development has become sufficiently pronounced in this field that the committee has allocated an entire chapter of the report to its consideration.

7. The management and accessibility of data needs immediate attention.

Thus far social scientists have not confronted systematically issues related to the management and accessibility of data—from its original collection and analysis, to its longer-term storage and maintenance, and to ensuring its accessibility over time to multiple users. What the committee has termed the ''hazards and disaster research informatics problem'' is not unique to this research specialty, or to the social sciences, natural sciences, and engineering generally. But the informatics problem demands immediate attention and resolution as a foundation for future research and application of findings.

8. How research is communicated and applied is not well understood.

More systematic research is needed on how hazards and disaster information generated by the social sciences and other disciplines is disseminated and applied. Such research will provide clearer understanding of what can be done within hazards and disaster research to further the dissemination of knowledge, thereby advancing sound mitigation, preparedness, response, and recovery practices.

9. A more diverse, interdisciplinary, and technologically sophisticated social science workforce is needed in the future.

Given the national and international importance of natural, technological, and willful disasters, the next generation of social scientists studying these events should become larger, more diverse, and more conversant with interdisciplinary perspectives and state-of-the-art research methods and technologies than the previous generation.

Recommended Improvements to Hazards and Disaster Research

Grounded in the above conclusions, the report offers 38 separate recommendations for improving how hazards and disasters research in the social sciences is conducted and used to inform policy and decision-making. The recommendations, the majority of which relate to the need for comparative studies of societal responses to natural, technological and willful hazards and disasters, are encapsulated in the following three summary recommendations.

Summary Recommendation 1:

Comparative research should be conducted to refine and measure core components of societal vulnerability and resilience to hazards of all types, to address the special requirements of confronting disasters caused by terrorist acts, and to advancing knowledge about mitigation, preparedness, response, and recovery related to disasters having catastrophic physical and social impacts. The recommended comparative research is essential for isolating common from unique aspects of societal response to natural, technological, and willful hazards and disasters. A key contribution of NSF through NEHRP over the years has been that, while necessarily emphasizing

earthquakes, since its inception the program has encouraged and supported comparisons of societal responses to earthquakes with other natural as well as technological hazards and even with terrorist induced events, though less so. This historical emphasis within NEHRP dictates that a rigorous approach should prevail in making generalizations to terrorism and that there is a continuing need for systematic comparisons of all societal hazards and disasters using the conceptual and methodological tools summarized in this report. A comparative perspective should be sustained within NSF and also prevail in the new DHS.

Summary Recommendation 2:

Strategic planning and institution building are needed to address issues related to the management and sharing of data on hazards and disasters (hazards and disaster informatics), sustain the momentum of interdisciplinary research, advance the utilization of social science findings, and sustain the hazards and disaster research workforce. Of particular importance because of its direct relationship to Summary Recommendation 1 is the call for strategic planning to address issues of data management and data sharing. A Panel on Hazards and Disaster Informatics should be created to guide these efforts. The Panel should be interdisciplinary and include social scientists and engineers from hazards and disaster research as well as experts on informatics issues from cognitive science, computational science, and applied science. The Panel's mission should be, first, to assess problems of data standardization, data management and archiving, and data sharing as they relate to natural, technological, and willful hazards and disasters, and second, to develop a formal plan for resolving these problems to every extent possible within the next five years.

Summary Recommendation 3:

NSF and DHS should jointly support the comparative research, strategic planning, and institution building called for in Summary Recommendations 1–2. The proposed leveraging of NSF with DHS support is critical because these two agencies are focal points of federal funding for research on all types of extreme events. The two agencies should take advantage of opportunities to leverage their resources by jointly funding social science hazards and disaster research whenever possible. This could lead to a better understanding of the similarities and differences between natural, technological, and human-induced hazards and disasters. It could also provide the foundation for sound science-based decision-making by policy-makers and practitioners, whether they are developing measures to counter a major natural disaster like Hurricane Katrina or a terrorist-induced event like the September 11th attacks on the World Trade Center and Pentagon. Social science research on the September 11, 2001 terrorist attacks as well as more limited observations that have been made thus far on Hurricane Katrina indicate, first, that many previous findings about societal response to hazards and disasters remain valid, and second, that there is still much to be learned about responses to truly catastrophic events.

Source: *http://dels.nas.edu/dels/rpt_briefs/facing_hazards_brief_final.pdf*

Attachment 2
Committee on Disaster Research in the Social Sciences (2006)
Specific Research Recommendations

Number	Recommendation
3.1	Research should be conducted to assess the degree to which hazard event characteristics affect physical and social impacts of disasters and, thus, hazard mitigation and preparedness for disaster response and recovery.
3.2	Research should be conducted to refine the concepts involved in all three components (hazard exposure, physical vulnerability, and social vulnerability) of hazard vulnerability analysis (HVA).
3.3	Research should be conducted to identify better mechanisms for intervening into the dynamics of hazard vulnerability.
3.4	Research should be conducted to identify the factors that promote the adoption of more effective community-level hazard mitigation measures.
3.5	Research should be conducted to assess the effectiveness of hazard mitigation programs.
3.6	Research should be conducted to identify the factors that promote the adoption of more effective emergency response preparedness measures.
3.7	Research should be conducted to assess the extent to which disaster research findings are being implemented in local emergency operations plans, procedures, and training.
3.8	Research is needed to identify the factors that promote the adoption of more effective disaster recovery preparedness measures.
3.9	Research should be conducted to develop better models to guide protective action decision making in emergencies.
3.10	Research is needed on training and exercising for disaster response.
3.11	Research should be conducted to develop better models of hazard adjustment adoption and implementation by community organizations.
3.12	There is a continuing need for further research on hazard insurance.
4.1	Future research should focus on further empirical explorations of societal vulnerability and resilience to natural, technological, and willfully caused hazards and disasters.
4.2	Future research should focus on the special requirements associated with responding to and recovering from willful attacks and disease outbreaks.
4.3	Future research should focus on the societal consequences of changes in government organization and in emergency management legislation, authorities, policies, and plans that have occurred as a result of the terrorist attacks of September 11, 2001, as well as on changes that will almost certainly occur as a result of Hurricane Katrina.
4.4	Research is needed to update current theories and findings on disaster response and recovery in light of changing demographic, economic, technological, and social trends such as those highlighted in Chapter 2 and elsewhere in this report.
4.5	More research is needed on response and recovery for near-catastrophic and catastrophic disaster events.
4.6	More cross-societal research is needed on natural, technological, and willfully caused hazards and disasters.
4.7	Taking into account both existing research and future research needs, sustained efforts should be made with respect to data archiving, sharing, and dissemination.

Committee on Disaster Research in the Social Sciences (2006)
Specific Research Recommendations (continued)

5.1	As NSF funding for the three earthquake engineering research centers (EERCs) draws to a close, NSF should institute mechanisms to sustain the momentum that has been achieved in interdisciplinary hazards and disaster research. Network for Earthquake Engineering Simulation (NEES)
5.2	The hazards and disaster research community should take advantage of current, unique opportunities to study the conditions, conduct, and contributions of interdisciplinary research itself.
5.3	NSF should support the establishment of a National Center for Social Science Research on Hazards and Disasters.
6.1	Priority should be given to international disaster research that emphasizes multiple case research designs, with each case using the same methods and variables to ensure comparability.
6.2	Common indicators of disaster risk and development should be constructed.
6.3	Collaborative international research projects should be the modal form of cross-national research on disasters and development.
7.1	The National Science Foundation and Department of Homeland Security should jointly support the establishment of a nongovernmental Panel on Hazards and Disaster Informatics. The panel should be interdisciplinary and include social scientists and engineers from hazards and disaster research as well as experts on informatics issues from cognitive science, computational science, and applied science. The panel's mission should be (1) to assess issues of data standardization, data management and archiving, and data sharing as they relate to natural, technological, and willful hazards and disasters, and (2) to develop a formal plan for resolving these issues to every extent possible within the next decade.
7.2	The National Science Foundation and Department of Homeland Security should fund a collaborative Center for Modeling, Simulation, and Visualization of Hazards and Disasters. The recommended center would be the locus of advanced computing and communications technologies that are used to support a distributed set of research methods and facilities. The center's capabilities would be accessible on a shared-use basis.
7.3	The hazards and disaster research community should educate university Institutional Review Boards (IRBs) about the unique benefits of, in particular, post-disaster investigations and the unique constraints under which this research community performs research on human subjects.
8.1	Renewed attention should be given by the social science hazards and disaster research community to the need for formal evaluation research on knowledge utilization in the field. New research should be carried out using all of the relevant methodologies and technologies available to the social sciences today.
8.2	Building on earlier practice, social scientists should conduct research utilization studies involving knowledge on hazards and disasters produced by other research disciplines.

Committee on Disaster Research in the Social Sciences (2006)
Specific Research Recommendations (continued)

9.1	Relevant stakeholders should develop an integrated strategy to enhance the capacity of the social science hazards and disaster research community to respond to societal needs, which are expected to grow, for knowledge creation and application. A workshop should be organized to serve as a launching pad for facilitating communication, coordination, and planning among stakeholders from government, academia, professional associations, and the private sector. Representatives from the NSF and DHS should play key roles in the workshop because of their historical (NSF) and more recent (DHS) shared commitment to foster the next generation of hazards and disaster researchers.
9.2	NSF should expand its investments in both undergraduate and graduate education to increase the size of the social science hazards and disaster research workforce and its capacity to conduct needed disciplinary, multidisciplinary, and interdisciplinary research on the core topics discussed in this report. NSF should also give special consideration to investing in innovative ways to further workforce development, especially when they involve partnerships such as NSF's recent joint initiative with the Public Entity Research Institute (PERI) and the Natural Hazards Research and Applications Information Center at the University of Colorado. This initiative, discussed below, exemplifies the collaboration needed across government, academia, professional associations, and the private sector.
9.3	In parallel fashion, DHS should make a conscious effort to increase significantly the number of awards its makes to social science students through its scholarship and fellowship program. Because much that must be investigated about the terrorist threat is related to social and institutional forces, more social scientists need to be recruited to adequately study them. With its broader cross-hazards congressional mandate, DHS should contribute to a larger social science hazards and disaster research workforce, one that complements research in other science and engineering disciplines.
9.4	NSF and DHS should consider ways that they can cooperate programmatically to enhance the social science hazards and disaster research workforce. Jointly sponsored university research and education programs by the two agencies would be of major benefit to the nation.
9.5	As the leader in furthering U.S. science through research and workforce development, NSF should make greater use of its enabling mechanisms, including standard research grants, center grants, grant supplements, and REU programs to attract more minorities to the social science hazards and disaster research workforce.
9.6	The NSF Enabling Project for junior faculty development (discussed below) should be continued if the second pilot proves to be a success.
9.7	Stakeholders in government, academia, professional societies, and the private sector should be open to exploring a variety of innovative approaches for developing the future social science hazards and disaster research workforce.

Source: http://www.nap.edu/openbook.php?record_id=11671&page=R1

BIOGRAPHY FOR MICHAEL K. LINDELL

Dr. Lindell has a Ph.D. in Social Psychology from the University of Colorado (1975) with a specialty in disaster research and has completed hazardous materials emergency responder training through the Hazardous Materials Specialist level. During his 35 years in emergency management, he has conducted research on the processes by which individuals and organizations respond to natural and technological hazards. In addition, he has provided technical assistance to government agencies, industry groups, and private corporations in development of emergency plans and procedures. His recent teaching duties have included one emergency management course at the undergraduate level (Introduction to Emergency Management) and three at the graduate level (Community and Organizational Response to Disasters, Disaster Recovery and Hazard Mitigation, and Disaster Response Planning). He has also served as an adjunct faculty for the Federal Emergency Management Agency's National Emergency Training Center, lecturing on disaster psychology and public response to warning.

Dr. Lindell has made over 170 presentations before scientific societies and in short courses for emergency planners in this country and abroad. He organized and chaired an American Society of Civil Engineers (ASCE) *Specialty Conference on Hazardous Facilities*, served on the ASCE Task Committee on *Natural Disaster Reduction*, and served twice as Secretary of the Executive Committee of the ASCE *Council on Natural Disaster Reduction*. He co-chaired the organizing committee for a conference on protective action decision-making in nuclear power plant accidents and was a member of the steering committee for a similar conference on protective action decision-making in chemical emergencies. He participated in the NSF's *Second Assessment of Research and Applications on Natural Hazards*, serving as a member of the committee on Preparedness and Response, and chairing the committee on Adoption, Implementation, and Evaluation of Hazard Adjustments. He has served seven times as a consultant to the International Atomic Energy Agency in developing planning guidance for response to nuclear and radiological incidents,

has made three presentations to National Academy of Sciences panels, and was a member of two National Academy of Sciences panels—*Disaster Research in Social Sciences* and *Assessing Vulnerabilities Related to the Nation's Chemical Infrastructure.* He recently served as an external reviewer for the National Oceanographic and Atmospheric Administration's *National Tsunami Hazard Mitigation Program* and the U.S. Department of Homeland Security's *Center for Studies of Terrorism and Responses to Terrorism,* and currently is a member of the National Earthquake Hazard Reduction Program's *Advisory Committee on Earthquake Hazard Reduction.* He has conducted research or provided technical services to 40 different organizations in the public and private sectors. In addition, Dr. Lindell has reviewed research proposals for 20 different foreign, federal, and State agencies as well as performing manuscript reviews for over 40 different journals in the social, environmental, and engineering sciences. He has written extensively on emergency management and is the author of 70 technical reports, 90 journal articles and book chapters, and ten books. He recently published a book on risk communication in multiethnic communities (Sage, 2004) and a textbook on community emergency planning (Wiley, 2006). He also completed an introductory textbook on emergency management under contract to the Federal Emergency Management Agency, a condensed version of which has been published by Wiley (2006). Dr. Lindell is currently the editor of the *International Journal of Mass Emergencies and Disasters.*

Chair WU. Thank you very much, Dr. Lindell. Dr. Harris, please proceed.

STATEMENT OF DR. JAMES ROBERT HARRIS, PRESIDENT, J.R. HARRIS & COMPANY, STRUCTURAL ENGINEERS

Dr. HARRIS. Thank you, Chair Wu, and Members of the Committee. Good morning. My name is James Harris, and I am pleased to be here as you consider reauthorization of the National Earthquake Hazards Reduction Program. By the way, I will typically refer to it as NERRP [National Earthquake Risk Reduction Program] because old habits die hard, and that is a fact of life.

I am a structural engineer. My business is designing structures, mainly buildings, to be useful and economical for their owners and to be safe for their users and the general public. NEHRP impacts what I do, and how well I achieve those objectives of my services. I am also a member of and affiliated with several other organizations that are deeply interested in the success of NEHRP, including the Structural Engineering Institute of the American Society of Civil Engineers, the Applied Technology Council, The Masonry Society, the American Concrete Institute, the American Institute of Steel Construction, the Building Seismic Safety Council [BSSC], and the Advisory Committee that Tom O'Rourke mentioned earlier.

My opinions are certainly informed and affected by all of those affiliations, but my opinions should be taken as my own statements. They are not really endorsed by any organization.

With regard to how the program has fared since the last reauthorization and the changes that were made, I believe the level of interagency coordination has improved and the effectiveness of the program is beginning to show the result of that improvement. In large measure this is due to the work of Dr. John Hayes, the man that NIST selected to become the director of the program in their agency, but of course he could not succeed without the backing of senior management at NIST. I have observed the agencies working together on the new Strategic Plan for NEHRP, and I have been impressed that they did collaborate strongly in putting that plan together.

It appears to me that the Interagency Coordinating Committee is a key element of making that cooperation effective, and I encour-

age Congress to maintain the emphasis that the highest levels of management in each of the NEHRP agencies be committed to the program. I do want to note my appreciation for the leadership that FEMA offered to the program in the past. Their focus on implementation of mitigation measures is very close to my central focus, and I think NEHRP has been singularly successful over the years.

There are opportunities for improvement. One obvious issue is that the appropriated funding of the program should reach the authorized levels. I appreciate that arriving at a federal budget is an awesome task, but I do want to note that the appropriated funds are less than either the authorized amounts or the proposed funding in the President's budget for fiscal year 2009. The Strategic Plan lays out a very ambitious program, but it does not contain budgets. The authorized funding levels provide a base level to work towards the goals of that plan, and any smaller amounts will simply delay progress. Another opportunity for improvement is to either deepen the commitment of DHS [Department of Homeland Security] to NEHRP or to enhance the ability of the earthquake program at FEMA to carry out its mission within the large and developing organization that is DHS.

With regard to the priorities for R&D funding, I certainly support the priorities set forth in the recent Strategic Plan for improving earthquake resilience of communities that is one of the overarching goals of that plan. It is not possible to achieve that goal without effective technology transfer. That is certainly close to my heart. The continued implementation of an expanded, coordinated program of problem-focused research and development in earthquake engineering, started at NIST in 2008 in response to strong recommendations from industry, is a key feature of NIST technology transfer. The recommended program includes systematic support of the seismic code development process, development of resources and tools to improve seismic design and construction productivity.

Another high priority item is continuing the FEMA-funded program to develop next-generation performance-based seismic design guidelines for new and existing buildings, and there is a program plan—I want to make reference to a NIST publication prepared with the assistance of BSSC called Research Required to Support Full Implementation of Performance Based Seismic Design. I want to highlight that to you as high priority R&D.

About the multi-hazard issue, as a structural engineer I am required to consider many natural hazards in the conduct of my practice. Earthquake, wind, snow, flood, ice and expansive soils all can have significant effects on the designs that I prepare. The role of the Federal Government in R&D is quite varied across these areas. Earthquakes are a prime example of a situation that requires a strong federal effort to make progress towards disaster resilience, and NEHRP is a shining example of a successful federal program. In my view the needs are not the same across this spectrum of hazards, but there are certainly unfulfilled needs.

On the engineering design side, earthquakes are unlike wind, snow, flood, or ice. That calls for a lot more support of engineering R&D in the earthquake area. On the natural hazard definition side the differences do not appear to me to be as significant, and the

whole idea of predicting the future from observation of the past is in the best tradition of strong science. The rarity of earthquake events certainly make it an interesting problem there.

I want to note that a recent survey of practicing engineers pointed to the wind load provisions of the standard that I am deeply involved, and which is the root of the building code provisions for structural safety. It is called "Minimum Design Loads for Buildings and Other Structures." It is published under the designation ASCE/SEI 7. The survey pointed to the wind load provisions being very difficult to understand, more so than the seismic design provisions, even though conceptually they are considerably more difficult, the seismic design provisions are. I attribute at least a part of that discrepancy to NEHRP because there is no equivalent of BSSC out there for wind engineering, and BSSC in no small measure has made our seismic design provisions all that much better.

So overall, I want to compliment the Congress for keeping NEHRP going. I want to encourage you to continue to do that, and I certainly support the idea of expanding into other hazards. Thank you.

[The prepared statement of Dr. Harris follows:]

PREPARED STATEMENT OF JAMES ROBERT HARRIS

Chairman Wu and Members of the Committee:

Good morning. My name is James Harris, and I am pleased to be here as you consider reauthorization of the National Earthquake Hazards Reduction Program (NEHRP). I am a consulting structural engineer employed at J.R. Harris & Company in Denver, Colorado. My business is designing structures, mainly buildings, to be useful and economical for their owners and to be safe for their users and the general public. NEHRP impacts what I do, and how well I achieve the objectives of my service.

I am also a member of and affiliated with several other organizations that are deeply interested in the success of NEHRP:

- I am currently the President of the Board of Governors of the Structural Engineering Institute of the American Society of Civil Engineers. SEI endeavors to serve the structural engineering profession and the public by continuously improving technical and professional practices. I am also a member and past Chair of the committee that produces the standard ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*, which is directly impacted by NEHRP.
- I am the immediate Past President of the Board of Directors of the Applied Technology Council. ATC is a nonprofit organization specializing in technology transfer to improve engineering practice to resist natural and other hazards. A majority of ATC's work is relevant to NEHRP and is performed under contract with FEMA and NIST.
- I am a member of the Board of Directors of The Masonry Society. TMS is a professional, technical, and educational association dedicated to the advancement of the knowledge of masonry. It produces standards for design and construction that are directly impacted by NEHRP.
- I am a member of standards development committees of the American Concrete Institute and the American Institute of Steel Construction, both of which produce standards for design and construction that are directly impacted by NEHRP.
- I am a member of various committees of the Building Seismic Safety Council, an arm of the congressionally-chartered nonprofit National Institute of Building Sciences. BSSC brings together nearly all the national, State, and regional organizations concerned with improving resistance to the effects of future damaging earthquakes.

- I am a member of the Advisory Committee on Earthquake Hazard Reduction, convened over the past two years by the National Institute of Standards and Technology, in response to the most recent reauthorization of NEHRP.

I cite all these activities and relations for two reasons: my testimony is certainly informed by each and every one of these affiliations, as well as others in the past, but my opinions are my own and must not be interpreted as the official position of any one of these organizations.

In your invitation, you asked me to answer four questions, and I will organize my testimony in that fashion.

Please comment on the level and effectiveness of interagency coordination and program performance since the previous reauthorization of NEHRP. Where are there opportunities for improvement?

I believe the level of interagency coordination has improved and the effectiveness of the program is beginning to show the result of that improvement. In large measure this is due to the work of Dr. John Hayes, the man that NIST selected to become the Director of the program in their agency, but of course he could not succeed without the backing of senior management at NIST. I have observed the agencies working together on the new *Strategic Plan for NEHRP*, and I have been impressed that they did collaborate strongly in putting that plan together. Thirty years ago I was an employee at the (then) National Bureau of Standards (now NIST) as NEHRP was being created. I know that cooperation of agencies across major departments of the Federal Government to jointly achieve programmatic objectives is not nearly as simple as might be desired. It appears to me that the Interagency Coordinating Committee is a key element of making the cooperation effective, and I encourage the Congress to maintain the emphasis that the highest levels of management at each of the NEHRP agencies be committed to the program.

I will cite two examples of recent interagency coordination with which I am personally involved:

- USGS and FEMA have worked together to prepare a significant update to the maps of seismic ground shaking hazard used for design of most structures. The activity began at least three years ago in a committee of the BSSC, and it incorporates results of the newest research on attenuation of ground motion waves with distance and a more sophisticated method of considering both the nature of the hazard and the nature of structural response to produce what we call "risk-targeted" ground motions. The new maps have been approved at BSSC and are well on their way to approval within ASCE 7. If all goes well the new maps will be the basis of building codes in cities and states within two to three years. This would simply not be possible without true cooperation between USGS and FEMA.
- FEMA and NIST are targeting their funds for the support of applied research in a coordinated fashion to move forward as rapidly as feasible a potentially promising method for systematic quantification of parameters used by structural engineers in design to resist earthquakes. In the past these parameters have been established mostly on the basis of professional judgment, which is a political process and subject to powers of persuasion. This new work offers the opportunity to exchange some of the subjective judgment with objective analysis. It appears to be eagerly sought by professionals in the field, and the accelerated testing of the methodology would not be possible without the cooperation of FEMA and NIST.

I do want to note my appreciation for the leadership that FEMA offered to the program in the past. Their focus on implementation of mitigation measures is very close to my central focus, and I think NEHRP has been singularly successful over the years. It appeared to me that FEMA's ability to lead the program was being impaired by the change from being an independent agency to being a part of the new Department of Homeland Security, and thus I supported the change directed by Congress to make NIST the lead agency.

In addition to the enhanced cooperation that I mentioned earlier, I believe that the change to NIST has truly made the program a four agency program. Even though NIST was listed as one of the four agencies in the past, their budget, and therefore their commitment to and effectiveness within the program became so small as to be inconsequential.

There are opportunities for improvement. One obvious issue is that the appropriated funding of the program should reach the authorized levels. I appreciate that arriving at a federal budget is an awesome task, but I do want to note that the appropriated funds are less than either the authorized amounts or the proposed fund-

ing in the President's budget in FY 2009. The Strategic Plan dated October 2008 lays out a very ambitious program, but it does not contain budgets. The authorized funding levels provide a base level to work towards the goals of that plan, and any smaller amounts will simply delay progress. Another opportunity for improvement is to either deepen the commitment of DHS to NEHRP or to enhance the ability of the earthquake program at FEMA to carry out its mission within the large and developing organization that is DHS.

What are the priorities for earthquake R&D to increase community resiliency? How well does NEHRP address these priorities? What would you recommend to ensure these priorities are addressed by NEHRP?

Please assess the technology transfer efforts supported by NEHRP. What would you recommend to improve the adoption of earthquake mitigation measures?

I will answer these two sets of questions together. I certainly support the priorities set forth in the recent Strategic Plan, and improving earthquake resilience of communities is one of the overarching goals of that plan. It is not possible to achieve that goal without effective technology transfer. Given my interest in design and construction, I will take this opportunity to highlight the activities necessary to support the objectives pertinent to those fields.

The productivity and effectiveness of the Nation's seismic design and construction community is affected by a variety of factors (see the ATC 57 report, *The Missing Piece: Improving Seismic Design and Construction Practices*, prepared in a project supported by NIST). These include

- the makeup of the industry, which consists of a large number of small design offices, clients, vendors, and contractors, who do not have the resources or business models for supporting research and development in seismic risk reduction;
- the complexity and wide variety of construction types, including buildings of varying height, size, and construction materials, and a wide range of transportation and utility infrastructure facilities;
- the ever expanding number of buildings and structures in the Nation's inventory, which naturally and routinely increases our exposure to seismic risk; (4) the availability of modern tools to improve efficiency; and
- the availability of new technology and information for reducing the effects of earthquakes on the built environment.

Future NEHRP plans must recognize and acknowledge these factors, and identify, promote, and fund actions that not only promote the development of new knowledge and methods for earthquake risk reduction, but also halt the ever widening gap between knowledge development and its application. The gap is one of the major factors affecting the decline in productivity of the U.S. design and construction industry over the last two decades (ATC–57). To this end, a wide variety of recommended actions are necessary, some of which are already underway. These include:

- The continued implementation of an expanded, coordinated program of problem-focused research and development in earthquake engineering, which was started by NIST in 2008 in response to strong recommendations from industry. The recommended program includes:
  - Systematic support of the *Seismic Code Development* process:
    - Provide technical support for the seismic practice and code development process, including research to support development of more rational methods for determining critical design variables;
    - Support the development of performance-based seismic engineering through the conduct of research to develop fragility information on the broad range of structural and nonstructural components for which such information is not available;
  - Improve seismic *Design Productivity:*
    - Support the development of technical resources (e.g., guidelines and manuals) to improve seismic engineering practice, focusing on structure types (e.g., infrastructure) for which guidelines are not currently available or no longer reflect the state of practice, or the state of research;
    - Make evaluated technology available to practicing professionals in the design and construction community through the development of technical briefs and other means;

- Develop tools to enhance the productivity, economy and effectiveness of the earthquake resistant design and construction process, including improved processes for computer aided design.

- Continued support of the FEMA-funded program to develop next-generation performance based seismic design guidelines for new and existing buildings, following the program plan that has been established for this purpose;
- Continued support of FEMA-funded programs for supporting mitigation activities necessary to improve technical quality in the field of earthquake engineering, including the investigation of seismic and related multi-hazard technical issues as they are identified by FEMA, the development and publication of technical design and construction guidance products, the dissemination of these products, and support of training and related outreach efforts based on these products;
- Expanded support of research being carried out under NSF-funded NEES Program, which was established to conduct research to improve the seismic design and performance of our nation's civil and mechanical systems, with improved coordination and planning of research to support the major development programs being carried out by FEMA and NIST;
- Expanded support of efforts to identify research needs from the perspective of design professionals and of efforts to coordinate research to enhance its effectiveness;
- New programs to encourage local communities to adopt and enforce programs to identify and reduce the numbers of seismically hazardous structures in their community;
- Involvement in international cooperative efforts, such as the Global Earthquake Model (GEM), to better understand and evaluate how seismic hazard, structural vulnerability, and seismic risk are characterized and determined by other countries, thereby enhancing the potential for improving our competitiveness world wide.

I am particularly hopeful about the performance based seismic design program. NIST has published *Research Required to Support Full Implementation of Performance-Based Seismic Design* (NIST GCR 09–917–2) making use of the assistance of BSSC that defines the needs. To me the work appears to be ground-breaking, and I believe there will be many ancillary, or spinoff, benefits to this research.

How should the Federal Government address R&D for other natural hazards? What opportunities exist to coordinate hazards R&D across the Federal Government?

As a structural engineer I am required to consider many natural hazards in the conduct of my practice; earthquake, wind, snow, flood, ice and expansive soils can all have significant effects on the designs that I prepare. The role of the Federal Government in R&D is quite varied across these areas. Earthquakes are a prime example of a situation that requires a strong Federal effort to make progress towards disaster resilience, and NEHRP is a shining example of a successful federal program. In my view the needs are not the same across this spectrum of hazards, but there are unfilled needs.

On the engineering design side, earthquake is unlike wind, snow, flood or ice. The nature of the action upon the structure couple with the extreme rarity and severity of strong earthquakes makes realistic a design strategy to accept significant damage to ordinary structures while still protecting against large loss of life. This brings a complexity to the engineering design and analysis that is simply unmatched in design for wind, snow, flood or ice. And this is the strongest underlying reason why so much R&D is necessary in earthquake engineering.

On the natural hazard definition side the differences do not appear to me to be quite as significant. Predicting the future from observation of the past is in the best tradition of strong science. The rarity of earthquake events does make seismology a challenging field, in my opinion, but I am sure there are comparable difficulties in meteorology.

I have long had a research interest in snow loads on roofs, and I think a contrast with the information available for definition of the hazard between earthquake and snow is instructive here. The USGS has done a very commendable job as the central focus for the applied science of defining the ground shaking hazard across the U.S. Their program does strongly benefit from the earth sciences research at NSF, and the USGS is very cooperative with the engineering community, especially in their interactions with BSSC. In ASCE/SEI 7, and therefore in the building codes used across the Nation, we directly incorporate the maps that are produced by USGS.

ASCE/SEI 7 also has hazard maps for snow, wind, and ice. These hazard definition maps are all produced by committee members in what amount to volunteer efforts.

The map for snow has a federal relation; the committee member most responsible was Wayne Tobiasson, an engineer now retired, who worked for the U.S. Army Corps of Engineers at their Cold Regions Research and Engineering Laboratory. It was not central to the role of the Corps; it was this man's professional convictions that led him to wade through available data from the Weather Service and the (former) Soil Conservation Service to prepare these maps. Even though the maps are extremely useful and the basis of our legal building codes, they have huge voids in mountainous regions where the snow loads are the largest, and the most difficult to discern. There is very little private sector incentive to collect, archive, and analyze the data necessary for the improved definition of the snow load hazard. In my opinion it is most appropriate for the Federal Government to fulfill at least the data collection and archiving of the information, if not the analysis. Yet the Weather Service has in recent years reduced their collection of information vital to predicting the weight of accumulated snow. The amount of money necessary is minor compared to the NEHRP budget, but there should be some way to accomplish the mission. The ASCE/SEI 7 map for ice has a similar story and a similar champion, Kathy Jones a scientist who also works for the Army Corps at CRREL.

The ASCE/SEI 7 map for wind speed is also produced by a volunteer committee. I know that this committee has heard testimony in the past concerning national needs for reducing the risk associated with high winds, and I will not attempt to repeat that here. But I will state that I certainly support increased federal support for R&D to reduce the consequence of high winds, including support for technology transfer. I previously stated that the engineering side of the earthquake problem is complex. I want to note that a recent survey of practicing engineers pointed to the wind load provisions of ASCE/SEI 7 as being very difficult to understand or apply (more so than the seismic design provisions of the same standard). I attribute at least a part of this discrepancy to NEHRP. There is no wind equivalent of BSSC, which FEMA has supported for nearly three decades. The critical mass assembled and the continuity at BSSC have in no small measure made our seismic design provisions better. We need similar help in the wind area.

I am confident that Katrina has focused the attention of the Federal Government on coastal flood issues. It appears to me that there are large public policy issues that need to be resolved, included the proper level of safety and the appropriate means for funding protection. I will say that the level of safety from flooding is considerably lower that the level of safety provided against other natural hazards. There are very likely benefits to be gained from coordinated social science, engineering, and physical science research on these public policy issues.

Overall, I believe that NEHRP stands as an example of how to assemble a critical mass of expertise to move the Nation forward. This has involved developing consensus on R&D priorities among all stakeholders, funding a wide group of interests to develop the expertise and to carry out the work, and focusing on implementation. These lessons can and should be applied to other natural hazards, but not at the expense of diluting the critical mass necessary for the synergy that has been realized.

BIOGRAPHY FOR JAMES ROBERT HARRIS

Experience

Jim is well versed in structural engineering practice and research. He has designed or evaluated hundreds of structures ranging from dwellings to high-rise buildings including industrial facilities, long spans, buildings in the highest seismic zones, excavation bracing, pile and pier foundations, vibration issues, and renovations of historic buildings. This background spans nearly all types of construction and structural materials and includes responsibility for management of all design disciplines. His experience includes six years of full-time research. His research has focused on the loading and response of structures, particularly earthquake and snow loadings. A second focus is on improving the formulation and use of engineering standards. He has written over 30 reports and journal articles on the results of his research and practice. He is an active member of several committees that produce national standards for structural engineering practice, and his expertise there was recognized by his election to the National Academy of Engineering.

Education

Ph.D.—University of Illinois, 1980, Structures and Foundations

MSCE—University of Illinois, 1975, Structures

BSCE—University of Colorado, 1968, Structures

Registration

Colorado: Professional Engineer #11118
Idaho: Professional Engineer #10309
California: Civil Engineer #34192; Structural Engineer #2640
National Council of Engineering Examiners Record #8449 (currently inactive)

Professional Employment

1984—J.R. Harris & Company, Principal, Denver
1981–84—Structural Consultants, Inc., Principal, Denver
1975–81—National Bureau of Standards, Center for Building Technology, Research Structural Engineer, Gaithersburg, MD
1973–75—University of Illinois, Graduate Research and Teaching Assistant
1969–73—Zeiler and Gray, Engineer and Associate, Denver
1968–69—Ken R. White Company, Engineer, Denver

Awards

- Distinguished Engineering Alumnus, University of Colorado, Boulder, 2007
- National Academy of Engineering, elected 2005
- Structural Engineering Inst. of the Am. Soc. of Civil Engineers, Walter P. Moore, Jr., Award, 2002
- Building Seismic Safety Council of the Nat'l Inst. of Bldg Sci, BSSC Honor Award, 1997
- Colorado Engineering Council, Certificate of Honor, 1997
- U.S. Federal Emergency Management Agency Outstanding Public Service Award, 1986
- U.S. Department of Commerce Bronze Metal Award for Superior Federal Service, 1981
- District of Columbia Council of Engineering and Architectural Societies National Capital Award for Special Achievement, 1981
- Univ. of Colorado Department of Civil Engineering, Ketchum Award for outstanding graduate, 1968.

Professional Society Membership

- American Concrete Institute; Fellow
- American Consulting Engineers Council
- American Institute of Steel Construction
- American Society of Civil Engineers
- American Society for Testing and Materials
- American Welding Society
- Coalition of American Structural Engineers
- Colorado Association of Geotechnical Engineers
- Earthquake Engineering Research Institute
- International Association for Bridge and Structural Engineering
- International Code Council
- The Masonry Society
- National Society of Professional Engineers
- National Trust for Historic Preservation
- The Post Tensioning Institute
- Structural Engineers Association of Colorado

Professional Committees and Activities (current)

- Advisory Committee on Earthquake Hazard Reduction (for the National Institute for Standards and Technology), Member

- American Concrete Institute: Member, Committee 318, Standard Building Code, and subcommittees on Seismic Provisions and on Prestressed and Precast Concrete
- American Institute of Steel Construction: Member of Task Committee on Seismic Provisions, Emeritus Member of Specification Committee; Former Chair, Committee for the Design for Blast Resistant Steel Buildings
- American Society of Civil Engineers: Member and Past Chair, Standards Committee for Minimum Design Loads for Buildings and Other Structures (ASCE 7); formerly Chairman, Task Committee on Earthquake Loads; also Member and Subcommittee Chair, Standards Committee for Loads on Structures During Construction
- American Society of Civil Engineers: Member, core team for the Pentagon to study building performance in the wake of the September 11, 2001, attacks
- Applied Technology Council: President, Board of Directors
- Building Seismic Safety Council: Member, Provisions Update Committee, Technical Subcommittee on Structural Design; Code Resource Support Committee; formerly chair of committee that produced 1985 edition of *NEHRP Recommended Provisions* (first edition), plus activity on several other technical subcommittees
- International Standards Organization, Past Chair of U.S. Technical Advisory Group for TC 98, Bases for the Design of Structures
- Mid-American Earthquake Engineering Research Center: Member, Executive Advisory Board (Chair 2002–3)
- Structural Engineering Institute of ASCE: President of Board of Governors; also former Chair, Executive Committee for Codes and Standards Activities Division
- Structural Engineers Association of Colorado: Chairman, Committee on Seismic Standards and Member, Committee on Snow Loads; President, 1990
- The Masonry Society: Member, Board of Directors

DISCUSSION

Chair WU. Thank you very much, Dr. Harris, and I just want to assure you that hearings are important. Concepts disseminate quickly, and Congress can respond. I think that we are going to call NEHRP, NERRP from now on, and we will just immediately make that change.

Dr. Hayes, many bouquets and accolades have been thrown your way and NEHRP's way in this hearing and through other reports, so let me ask you about something that you may or may not be doing correctly which is that there has been some testimony that the level of support for managerial and technical activities at NIST, that expanding that level of support would be integral to strengthening NEHRP. Why hasn't NIST requested the fully authorized funding levels and what other priorities might be met? And this is a question for the rest of the panel, and for you, Dr. Hayes. What other priorities could be met if those functions did have full funding at NIST?

Dr. HAYES. Sir, first, let me thank you for the accolades, but they are not that well-deserved. This is a teamwork operation that we have, and it involves partners from the other three agencies that are sitting behind me now. And without them, this wouldn't be successful.

Insofar as your question is concerned, the President's budget the last couple of fiscal years has requested increased funds for NIST, and we are really happy that this year in the 2009 budget we did see a very meaningful increase of about $2.5 million—$2.4 million to be exact—in the NIST research budget for supporting earth-

quake research. And we are in the process now of doing a couple of things. One is that we are working very diligently to rebuild the earthquake engineering workforce at NIST, and we have hired a couple of folks already and are looking to hire other people this summer and fall. We also have contract support that has been very helpful for us as well, and I think we are making really good headway toward improved size and scope for the program through the funding that came this year, and we anticipate seeing a gradual growth process. I think it would be unwise to do it all overnight, if you will, anyway. I think we have to be smart about the way we grow back into things, and we are very diligently doing that as we speak right now, interviewing people, trying to find good people for the team. So we are definitely making headway in that area, sir.

Chair WU. Well, Dr. Hayes, I think just between the lines, what I am saying is we are from the Congress, we are here to help, and consider the question asked about what expansions in this particular budget would help the functions of all of NEHRP.

Dr. HAYES. Thank you, sir.

Chair WU. Dr. Lindell, you stated that social scientists learn in one disaster things that can be applied across different kinds of disasters and to different disasters of the same kind. Could you address this a little bit for us, a couple of examples about lessons learned and whether this might argue for bringing different hazards together because of some commonality and avoiding some of the stove piping and replication of function?

Dr. LINDELL. Sure. I could provide a very large number of examples over the past 30 years, but I want to focus on one that is ongoing right now. About four years ago, my wife and I submitted a project proposal to the National Science Foundation in collaboration with Professor Harry Yeh and Cherri Pancake at Oregon State University. Their background was in tsunamis and in engineering. Ours was in social science and hurricanes. The four of us saw that there were substantial commonalities in our research because both of those are hydrological hazards, the storm surge in the case of hurricanes and the tsunami wave. There are some differences, but there are some similarities as well. And so the objective of a project that was funded by the National Science Foundation was to integrate some of the ideas that we had learned about how to evacuate from hurricanes. There has been a lot of research on hurricane evacuation over the years, not so much in the case of tsunamis. This project provided an opportunity to take what had been learned on hurricanes and apply that to tsunami research. And so that was a very profitable research area for us to engage in.

Other areas are ones where we have learned from research that we did on the accident at Three Mile Island in radiological emergency preparedness, as well as the toxic chemical accident in Bhopal and the subsequent toxic chemical emergency preparedness initiatives after that. Many lessons were learned, particularly in response to the *Superfund Amendments and Reauthorization Act*—the *Emergency Planning Community Right-to-Know Act of 1986*—which established local emergency planning committees. I did a study of local emergency planning committees in Indiana, Illinois, and Michigan that provided a lot of ideas about how to improve community emergency preparedness for earthquakes as well.

So those are just two examples, but like I said, there are many others as well.

Chair WU. Thank you, Dr. Lindell. My time has expired. I will come back with further questions.

The gentleman from Nebraska is recognized for five minutes.

Mr. SMITH. Thank you, Mr. Chair, and thank you to the panel for sharing your expertise. I stand here or sit here as a Nebraskan who has experienced, believe it or not, an earthquake in the mid-'80s. Fortunately, there was not a great deal of damage, but we have obviously other hazards. You know, perhaps there is overlap in some of the mitigating or planning circumstances, whether it is snow load, wind resistance, what have you, so some codes that help in one area probably helped in another.

When it comes to adoption of building codes, though, I am wondering if you could maybe give us an update, Dr. Harris, on the acceptance of the recommended building codes and maybe what we need to work on. I would also submit that sometimes building codes find their way into the law so to speak that maybe have other interests other than public safety and the value of property and so forth. But we do want to have the utmost of requirements or the intent to protect human lives and property. How would you respond?

Dr. HARRIS. Actually, the program has been very successful, but that doesn't mean it is universally successful in terms of affecting the building codes in cities and states across the Nation. The path to those building codes is a somewhat torturous path if you will. Almost all building codes are laws of cities or in some cases of states, and now almost all of those make reference to a model building code. There is one predominant model building code in this country called the International Building Code. With respect to the seismic safety issue as well as most other structural concerns, that model building code makes reference to lots of structural engineering standards. In other words, the safety provisions aren't really in the building code. They are in the referenced standards. The standard I mentioned earlier, the ASEC–7 standard, sets forth the loading side of it, and then there are lots of standards produced by other entities that set forth how you design in a given material, whether it be steel, concrete, masonry, or timber, for example.

The great success of the NEHRP program with respect to implementation, I think, has been FEMA's long and consistent support of the Building Seismic Safety Council, which is a forum that brings together all of these stakeholders that are interested in how seismic safety is promulgated through building codes.

It turns out that one national organization with 50 or 60 organizational members doesn't necessarily assure—when that group agrees that something ought to be done, it doesn't necessarily assure that every city is going to adopt it. And there are cities here and there that are, I think, for good reasons dragging their feet on moving into the best current practice for seismic safety. These are cities where the seismic hazard is high. Therefore, the cost of compliance is high. But the experience of earthquakes in a human lifetime isn't there because the event is such a rare event, and specifically I am talking about the Middle Mississippi Valley area. And

it is a serious concern as to how we best protect places like this where the event is so rare that, you know, a person of a decision-making age has never experienced an earthquake, nor is he related by blood to anyone who has, who is still alive. You are talking about the interplay then of social science with technical sciences, physical sciences, and it is a difficult sell. I think the program is doing a good job. It is not heavy-handed. It is relying upon consensus in these standards bodies. The model code building process has a semblance of consensus to it also. By the time it comes down to adoption in a particular city, the art of persuasion is particularly important, and it becomes a very political process.

But all I can say is that I think the NEHRP program has been more successful than any other federal program I am aware of in terms of bringing improved safety levels to bear more or less generally across the Nation. It is not a battle that is won, it has to continue to be fought.

Mr. SMITH. Okay. Thank you. My time has expired, so I will wait for the next round. Thank you.

Chair WU. The gentleman from New York is recognized for five minutes.

Mr. TONKO. Thank you, Mr. Chair, and thank you to our panel. Professor O'Rourke, we are both fortunate to claim New York as our work ground, and I just had a question of you as one in the area of civil engineering as to how you interact with researchers who are dealing with the social sciences of the research that needs to be done? How is that interaction put together?

Prof. O'ROURKE. I can give you some examples. For a number of years, we actually had support from the National Science Foundation to work with social scientists at the Wagner School of Public Service in New York City. This was a group of engineers but primarily social scientists who were in city planning, the applied social sciences with respect to decision-making, and that I think led to a lot of very interesting insights and some excellent opportunities to reach out to people in urban environments and begin to formulate approaches that would allow us to, number one, from the engineering and scientific side become aware and informed about the social dimensions of our technologies.

You know, it is one thing for us to be able to invent a new process or propose a new development or piece of infrastructure, but it is quite another thing for the communities to accept that because there is quite a lot of disruption. There is quite a lot of interference with the normal activities, and frankly, the lack of this coordination between social science and engineering and science, hard science, was actually getting in the way of getting important civil infrastructure projects put into place in a timely fashion. And as there has been a number of more effective ways of approaching this dialogue.

Just being able to support a continuing dialogue between the engineering professions and the social science professions has been extraordinarily important for enlightening both groups because you have to pay some serious translational fees when you try to find common language across both sides. But the final product has been, I think, exceptional, and I think very helpful for putting civil infrastructure into play. I made a comment before that real civil in-

frastructure are the communities, the actual people, that benefit from the physical infrastructure. So unless we can bring those two together, we are not really doing it in the holistic and correct way.

Mr. TONKO. And are there major impediments to that interaction that you believe we need to address in order to make the work more effective?

Prof. O'ROURKE. Yes, there are. For example, there are institutional impediments. If you look at civil infrastructure, it is actually, if you want to use the word, Balkanized. You will have water supply and power and telecommunications with entirely different corporate cultures, different reward systems, different agenda. And so getting everybody to sort of sing in the same choir and getting everybody to coordinate properly on the process is an extraordinarily important part of getting this job done. We don't depend on just one system at a time, we don't just rely on water supply for fire following a major disaster like an earthquake or a World Trade Center disaster, we don't just depend upon electric power, we depend upon them all concomitantly and at the same time; and therefore, dealing with the interdependencies, both physical, interoperational, and institutional, becomes a very, very important part of how we proceed.

Mr. TONKO. Thank you. Dr. Harris, you had, in earlier questioning, spoken to disasters that have huge amounts of wind-related to them. I am assuming that wind speed maps become critical when it comes to design. Who do you rely upon? Is NEHRP there to provide these bits of data or how simply do you get the details that you need, the maps that you may need for wind speed?

Dr. HARRIS. Thank you for your question. NEHRP actually doesn't have anything to do with the maps that we use for wind speed. They are produced in a committee by volunteers, a committee of the American Society of Civil Engineers. These volunteers make extensive use of data that is compiled in something called a National Climatic Center which is related to NOAA [National Oceanic and Atmospheric Administration] and the National Weather Service. But the analysis of the data is pretty much purely done by volunteers who put this map together, responding to overall community decisions on how safe is safe enough. The overall wind program, if you will, if it were supported as proposed in the National Wind Hazard Impact Reduction Program, I think would become more sophisticated and a better overall program, probably more intelligent expenditure of construction dollars. I think it would reduce cost in some areas and would increase cost in others because the safety level would become more consistent then.

Mr. TONKO. Thank you. Thank you, Mr. Chair.

Chair WU. I thank the gentleman from New York. The gentleman from Nebraska is recognized for five minutes.

Mr. SMITH. Dr. O'Rourke, you noted or you referenced FEMA's support for earthquake preparedness has been perhaps subsumed into a more generic State and local hazard preparedness program, and obviously FEMA always has a lot on their plate it seems. And with the so-called moving target of geography of disasters and the velocity of disasters, certainly I don't want to criticize FEMA, but would you believe there are ways to reestablish a good, distinct

focus on earthquake mitigation within FEMA without compromising this all-hazards mission and approach within DHS?

Prof. O'ROURKE. Absolutely. I think in order to make any hazards mitigation effective, you have to get down to the community level. That is where the implementation occurs, and FEMA, frankly, has been quite effective in being able to reach out to the communities. As envisioned within NEHRP, FEMA is the implementation arm. They are the group that works through the codes and standards process. They are the group that developed HAZUS which is applied at the local community level, and they are the folks that come in and work with the states and multi-State organizations and so forth. Their support for the State program, since about 2003, has been subsumed into a broader sort of DHS approach to things, and there has been kind of a loss of identity during that period of time on the part of the State managers and mitigation and earthquake programs. We believe that those programs were very effective because they were targeted, people did have an identity, they were able to get access to resources that made them effective, and putting more emphasis on the State programs, in particular, for mitigation programs within the states' targeted earthquakes is a good idea, that it doesn't necessarily compete with other hazards. It fits into a jigsaw puzzle as a complimentary piece of support with other types of hazards. And actually, it is kind of a natural, shall we say, stimulus for support and other hazards area, and I will give you an example. When HAZUS, which is this computer decision support system that is very effective in helping communities understand the impacts of natural hazards and their local jurisdictions, was originally created, it was created for earthquakes. But since then, it has been extended to floods and to windstorm effects. So starting from the incubation of this particular technology for earthquakes, it has been able to be developed and applied to other locations.

Mr. SMITH. Thank you. And then also, Dr. Harris, if you might respond. Certainly there is a lot of discussion lately about carbon footprint and the impact of carbon emissions. Do you see any of these efforts perhaps compromising building codes along the way?

Dr. HARRIS. If they were applied in an unthinking fashion, that might be the case, but in reality, I think the smallest carbon footprint, with respect to the topics we are talking about, is building the infrastructure that is the most resilient, that you don't have to reconstruct after every natural disaster. And it does mean in some cases spending more money and more carbon in the initial construction because it pays off in the long run. If you look at the carbon footprint issue as a true life cycle cost, then I don't think there are conflicts. If it gets narrowed to just carbon in a given year, then perhaps there are conflicts.

Mr. SMITH. I appreciate your response. I hear you saying that there may need to be some flexibility and that we should look beyond perhaps just that first carbon footprint and what might happen down the road.

Dr. HARRIS. I concur. That is the flexibility that is necessary.

Mr. SMITH. Thank you very much.

Chair WU. The Chair recognizes himself. Dr. Hayes, you testified that NEHRP has almost 30 years' worth of experience at inter-

action with State and local government and other earthquake professionals which has provided a good deal of organizational experience that can be shared with those working with other hazard fields. What lessons are the lessons learned from earthquakes and how can these lessons be extended to other hazard fields?

Dr. HAYES. I probably won't think of all of them. There are many similarities, and there are some dissimilarities and we have to distinguish between the two. But I think as Dr. Lindell testified earlier, one of the major areas of possible commonality is in the disaster preparation and response recovery that really involves many activities that are very similar. It is irrelevant what the hazard might be. There are other issues that we clearly see involve work that NEHRP has done over the years. But for example, cascading effects that can occur in the lifeline systems of a community that is impacted by any natural disaster, whether it is a flood, tsunami, earthquake, wildfire, where one system is impacted that then affects another system is another area that has many areas, I think, of common interest.

Looking specifically within the structural world, we certainly see that there are some similarities with wind effects but not close similarities between wind effects and earthquake effects. There are things that can be learned there, and again, looking more narrowly at structural engineering, if we look at what we call progressive collapse, which in effect is a cascading effect, there are similarities there as well. When a structural element fails, it almost doesn't matter really what the original impetus was that caused that failure to occur if things start spreading throughout a structure. And so there are similarities there, and it is something that I think we haven't completely studied in a comprehensive way yet, and it is certainly something that could be done in the future.

Chair WU. Thank you, Dr. Hayes. Mr. Murphy, what type of activities does NEHRP currently support with respect to tsunami, and what are some other things that NEHRP perhaps ought to be looking at with respect to tsunami preparedness?

Mr. MURPHY. I think probably the most—what I consider significant and beneficial thing—that NEHRP provides is the support of our public education and warning campaigns. I think the most significant thing as you know, Mr. Chair, there is not a whole lot of time to evacuate and not a whole lot of space on the Oregon coast, and I will only speak for our area, but public education not only to the citizens but to the visitors to the states that may not be familiar. So, I think those types of programs and financial support to help us makes a huge difference, and I think that would apply to any state as you look at these.

I think also, too, you know, as far as NEHRP goes, you know, the more tools that at least in the emergency management community can be provided, you know, not necessarily for us but through the science, you know, to help us know as soon as we can about it or the potential resulting after-effects. I think the science is very important, and I know I have learned a great deal from our geologists, our seismologists, our civil engineers, you know, and using those to try and predict through HAZUS as has been mentioned here, the modeling system, you know, and I think the continued support and hopefully increasing support in those areas will help

us do a better job as emergency managers trying to prepare for it. And whether it is in the preparation mode or the response or recovery mode, any of those types of tools that NEHRP has provided or can provide would help us in the future.

Chair WU. Thank you very much, Mr. Murphy, and Mr. Tonko?

Mr. TONKO. Yes, thank you, Mr. Chair. Prof. O'Rourke, you recommend a post-earthquake information management system. Can you further detail that for us, please?

Prof. O'ROURKE. When people come into an earthquake stricken area, there are many, many different forms of data that they collect. They may collect photographs, they may collect high-resolution satellite imagery, they may collect observations, they may collect actual information about the subsurface soil conditions. These then become somewhat extraordinarily complex as the information starts to come in. And the intention, of course, is not to have this information just available to a few individuals who are expert in the area but to make it generally available to the community at large and ultimately to the community that has been affected or may be affected by the next event. And it is not a trivial task to try to take all of these disparate sources of information and integrate them into a system where people can get access that their appropriate metadata which are data that allow them to identify where the specific information is that they are looking for and to create that in a user-friendly way. The earthquake community, I think, has kind of led the group in terms of acquiring information after disasters and have experimented with a number of, I think, very exciting technologies. One of the areas that they piloted has been the use of high-resolution satellite imagery that has been tied into GPS systems on the ground so that as people acquire information as they travel through earthquake-stricken areas or disaster-affected areas, this information is immediately integrated into the satellite view of things and then is integrated by advanced geographical information systems into a whole series of databases which are map-based. And this was done for earthquakes in the 1990's and early 2000 and actually has been very effective in acquiring information after hurricanes, like Hurricane Katrina and Hurricane Rita. And so this is a part of that type of information system where we are looking for high-tech, very visual, very precise, very visual ways of collecting and cataloging that information for access by others.

Mr. TONKO. Then who do you envision would be responsible for implementation?

Prof. O'ROURKE. That is an integrating role, and I would look to the integration of post-earthquake information to the lead agency which would be NIST because that would be the natural place to place that type of oversight. And I know that NIST in the previous year has actually supported some workshops that have been focused on trying to acquire, and FEMA has also been in part of this. Of course, FEMA is important because of the implementation part of it. Ultimately, as I mentioned before, one of the important applications for this information is in the actual community where the problems have occurred. When you have to reconstruct after a major earthquake like Northridge or you have to reconstruct after a major hurricane like Katrina, you need to have this type of infor-

mation with the planners and the civil engineers and the public utilities and the communities so that they have that data available to do the most effective job on reconstructing their environments.

Mr. TONKO. It sounds like it would provide some good preventative therapy, too, in the response that would be required in situations that would follow after those given circumstances.

Prof. O'ROURKE. Absolutely.

Mr. TONKO. Mr. Murphy, you shared the thought that perhaps we should look at geographic constructs with the reauthorization of NEHRP. Could you describe that for us, please?

Mr. MURPHY. Yes, sir. Really trying to focus NEHRP programs is a priority, so that we ensure that we are good stewards of the money in the NEHRP program. In looking at trying to focus the program we need to ensure that there's clear evidence like the New Madrid earthquake fault which runs through the Central United States. It includes eight states. Out in my part of the United States, the Cascadia Subduction Zone that affects Alaska, Washington, Oregon, and Northern California and you know, where we have clear, good, empirical data if possible that we try and focus the money and efforts to help in those areas that clearly have evidence and that we can spend the time, whether it is in preparedness mitigation, response, or recovery to focus that effort toward those geographical areas.

Mr. TONKO. Thank you.

Chair WU. I thank the gentleman. Dr. Harris, given the number and magnitude and the frequency of wind-related disasters such as hurricanes and tornadoes, why do these wind-related disasters receive comparatively, it seems, less attention in codes and the standards development process, and what is the wind equivalent of the Building Seismic Safety Council?

Dr. HARRIS. The engineering problem is actually approached in a different fashion. The nature of the earthquake action on a structure allows one to take advantage of certain kinds of damage and still protect life, at the risk of losing substantial dollars of constructed inventory, but when one does a cost benefit analysis, that makes sense. So what it means then from the engineering side is that the solution of a design to resist an earthquake is a very complicated problem.

For the solution to designing the structure to resist wind, or in fact any load that is related to gravity, snow on the roof, occupancy within the structure, and so on, a much simpler approach is taken. Effectively it is the difference between, you know, let us say a college education and a post-graduate education in terms of the level of the sophistication of the structural design. That has driven the need for an extensive R&D program in earthquake engineering, if you will, not necessarily hazard definition, in the engineering side of it, which we haven't had to have for wind. So there is less attention paid, if you will, in building codes and building code development processes to the wind problem than there is to the earthquake problem. But in the end, it turns out that it is to all of our detriment. It turns out that the provisions we have are not as clear and easy to understand. They don't have the same, I think, depth of technical consensus behind them that we do in the earthquake world.

The equivalent to BSSC for wind is in fact a subcommittee of this ASCE–7 committee that produces the standard on ''Minimum Design Loads for Buildings and Other Structures.'' There are roughly 30 to 40 highly qualified professionals involved in that volunteer committee, and they do what BSSC does, if you will, but for wind. They produce the map, they produce the provisions. The fact that it is a volunteer effort means that it is just—it doesn't receive the same attention.

Chair WU. Dr. Harris, this is stunning. What you are saying is that because it is a simpler problem and easier problem, wind resistance and codes concerning wind resistance receive less attention than seismic research and resistance to seismic stress, even though on a per-dollar basis and on a per-life basis it might be a higher risk?

Dr. HARRIS. Yes, both parts of your statement are right. It receives far less attention in the research community, it receives less attention in the code development processes, and in reality, year in, year out we lose lives and we lose property because of high-wind events. It is my personal opinion that this society in this country continues to move toward a desire for increasing levels of safety which means that in the end we are going to have some very difficult technical problems to solve on the engineering side because we are going to soon be at the point where I think we can no longer say, ''it is a tornado,'' and ''we do not design for tornadoes,'' and that becomes a very difficult problem to solve then.

Chair WU. So on a per-dollar-spent basis, there might be a lot more bang for the buck in research on structures and developing codes, promulgating better codes for wind resistance?

Dr. HARRIS. I concur with that.

Chair WU. Just very quickly for the entire panel, as my time is winding down here, the report, Securing Society Against Catastrophic Earthquake Losses, recommends $330 million per year over 20 years to achieve national resiliency for earthquakes. What could be done with a triple-fold increase in funding, and that is a difficult thing to do, but what could be done with a triple-fold increase in funding and how might that help both our mitigation and our preparation steps?

Prof. O'ROURKE. That report that you refer to was put together by quite a distinguished group of multi-disciplinary people who have thought about it for a long time. That kind of level of support would accelerate, and acceleration is important because the risk increases constantly. Activities that are already under way and then would provide the kind of strength and basis to deliver on the products. We have heard, for example, about a number of the areas that deserve research. That would be able to be accomplished by that type of level of funding. For example, the performance-based seismic design. It is a very tricky problem because you are trying to deal with the design of the structure to fit a certain level of performance in terms of what the owner would desire from that structure, and that performance, which is translated into human terms has to then be linked to computer analyses and methods of assessment and then also the level of seismic risk. So there is a lot of effort that goes into that. It is a very important part of making

communities resilient, and that would be able to be accelerated and put into place.

Similarly, one of the areas that I think is a tremendous opportunity for the entire country is understanding the interdependence of complex lifeline systems. We know from not only earthquake events but from issues relating to hurricanes and other kinds of natural disasters that there are tremendous interdependencies among these systems, and I will give you an example. After Hurricane Katrina, there was virtually all the infrastructure in place to take oil from the Louisiana off-shore oil part, and take it on the pipeline system because that was buried. It wasn't affected by the hurricane—and take it into the Midwest where it was absolutely necessary for energy. But it was unable to function because the pump stations were without electricity having had those transmission lines blown down and substations under water because of Hurricane Katrina.

So these interdependencies and understanding them and earthquakes have really led the way because of the large geographic extent of the damage and the interdependencies and the interaction and all these different functionalities have really helped being illustrated. And there have been a number of sophisticated models that have been put forward. This kind of work could accelerate, and I think not only do you end up with that type of support securing this country against earthquakes, but you have an enormous additional benefit in terms of the technology, the procedures, the processes that spread out and are applied to all sorts of hazards, including human threats in the form of major accidents and then also terrorism.

So a lot of what is done in the earthquake area affects other hazards, and it also affects our critical civil infrastructure. And trying to leverage this kind of support, this kind of investment we make in the earthquake area to affect our civil infrastructure, make it better—you know, if you can make civil infrastructure better during an earthquake, I guarantee you, you have made it better for everything.

Dr. HARRIS. I would like to add to Tom's remarks just a little bit and say that a substantial increase would allow, I think, a lot more attention to be paid to the substantial problem of evaluating and rehabilitating existing structures, especially in the area where earthquake hazards is of the nature where it occurs relatively frequently. No place is it truly frequent but relatively frequently. We have a tremendous inventory of built construction that is not earthquake resilient, and the real money is making those structures resilient. Increasing the funding for the program in a substantial way is the first step toward figuring out how we come up with the right economic models to fund the rehabilitation of existing hazardous construction. There is a strong tradition in the regulation of buildings: laws are not made retroactive. There are a few sterling exceptions, such as the invention of the smoke detector a little bit less than a half-century ago, which led to building code provisions that existing structures had to be retrofitted with smoke detectors because it was such a low-cost item and saved so many lives. We don't have that analogy for almost anything that is structural, and so private sector buildings, there are no mandatory—they are very

limited, pardon me—mandatory, retroactive provisions in building codes to reduce existing hazards.

Chair WU. Is there an exception for that, say, in the San Francisco Bay area that when you redo even a residential structure that you have to upgrade the structure?

Dr. HARRIS. Yes, and these rules are complicated as you might expect. When you are giving essentially extended life to existing buildings, there are rules that vary from one jurisdiction to another as to whether you have to actually even evaluate the existing seismic hazard, and then if you do have to do that, what you have to do in terms of upgrading. It is unusual that you would have to bring existing structure up to the level expected for new construction. And the rules are not necessarily consistent. FEMA has been working on this problem for a long time. They have supported the development of tools that the engineering profession is finding useful, but the engineering profession also finds gaps, holes, et cetera, in these tools. The enhanced funding could accelerate this process so the engineering tools are better, and frankly there has to be the public policy side of this to decide how we are actually going to get things implemented.

Chair WU. Thank you. Would the gentleman from New York like to ask any further questions?

Mr. TONKO. No, Mr. Chair, I am set. Thank you.

Chair WU. Thank you very much then. Let me move toward closing, and I would like to ask a question of Dr. Lindell or anybody else who would like to respond, and this is a curiosity/speculation question.

Dr. Lindell, in your testimony earlier you said that depending on social, economic and other factors of the population affected, there are potentially different responses or different outcomes to various disasters. And I would just like to invite you to speculate for me. And if this is something to which you have not devoted any professional thought, I am fine if you decline to speculate. But one natural, one man-made disaster, if you will, if Hurricane Katrina had hit a different city with a different ethnic makeup, a different social economic mix, what kinds of outcomes, what kinds of reactions might have been different. And similarly, instead of the airplanes crashing into the World Trade Center on 9/11 if say that had happened—you are at Texas A&M—and if those airplanes had crashed into buildings or a school where there are 3,500 kids in Houston rather than two office towers in New York City, how might things have been different. And if you are comfortable speculating about those scenarios, I would invite you to illuminate the situation for me.

Dr. LINDELL. I am a professor, and so speculation is my profession.

First, regarding Hurricane Katrina, I think it is instructive to note that in 1992, Hurricane Andrew struck Miami. Andrew was actually a stronger storm. It was at the top of the category four and was subsequently reclassified as a five on the Saffir-Simpson scale. Even though it was actually a stronger storm than Hurricane Katrina, it created fewer casualties, less damage, and less long-term disruption. Now, part of the reason for that—as a matter of fact, we know a number of the reasons why there was such a big

difference between Andrew and Katrina. First of all, we know that much of New Orleans is below sea level and that Katrina had a stronger surge than Andrew did. And so the hazard exposure of the city made a difference. Had the land use plans in the City of New Orleans prohibited development in areas, let us say, below 10 feet below sea level, the damage and death toll probably would have been much less. Had the building codes required elevation of the structures so that they could withstand the flooding of the city, the damage and the death toll would have been even smaller. Those land use plans and building codes deal with hazard exposure and physical vulnerability, respectively. There is also social vulnerability, which is another preexisting condition. We know that some of the greatest damage and the greatest death tolls were in areas where people were in lower income, lower education, population segments and were ethnic minorities, as well. All of these are indicators of or predictors of social vulnerability. These were people that didn't have the cars to—they either had no cars to evacuate, had cars that were not sufficiently reliable to travel out of the city, or had insufficient funds to be able to travel outside the city for an extended period of time. Because all their relatives lived in the city, they didn't have any relatives or other people that they could stay with because that is where most people who evacuate do stay. Few people go to public shelters: it is usually only a maximum of about 15 percent in most cases. Most people stay with friends and relatives, or if they have the money, they go to commercial facilities, hotels and motels.

So those are a few ways in which the consequences would have been different had it been a city that had a lower proportion of ethnic minorities or households with low incomes. On the other hand, what if there had been compensatory measures that had recognized adequately the social vulnerability, the physical vulnerability and the hazard exposure? That is, what if the local emergency plans had provided for the training of bus drivers and made arrangements to ensure that bus drivers would have been there to drive the school buses that many pictures show were flooded out, that were never used for evacuation? So had there been better mitigation measures, better emergency response preparedness, and better disaster recovery preparedness measures; had there been a higher proportion of people that not only had flood insurance but had a flood insurance and also homeowner's insurance through high-quality insurance companies.

One of the things that was found in Hurricane Andrew is that many of the ethnic minorities and lower income population segments had their homeowner's insurance with regional companies that went bankrupt. They either got nothing or got a very low payment on their losses, sometimes what happened was that it took a very long time to go through the State of Florida to get any kind of funds for reconstruction.

So there are all these social science factors. We have talked about building codes, but it takes political will within a jurisdiction to get those codes adopted, implemented, and to get the inspections done to make sure that they are actually effectively implemented. So there are a large number of social science issues that follow on from just about all of the physical science and engineering issues

that relate to this question of how would things have been different if there was good physical science and engineering research. It could have been different but only if that research was properly implemented.

Chair WU. Thank you, Dr. Lindell, for that very thoughtful response. I think that underscores the Science Committee credo that information is important and the opportunity to think about it is very, very precious.

I want to start something new with this subcommittee here. We have gone on for a while, but I want to turn it back over to the panel. If the panel has anything else to add because it occurs to me that you all have traveled, many of you significant distances, and in the course of a dialogue like this, I think one of the most frustrating things is to have come a long distance and to sit there with a sense of, you know, I have something to say about that or if the guy just asked me a different question. So consider the question asked, and we will take just a couple minutes so that if there is a burr under your saddle blanket, please proceed in whatever order.

Dr. HARRIS. I will offer one thing which follows directly, I think, some of Mike's comments about Katrina, and one of the things that has become clear in my service on committees writing things that end up in building codes is that fundamental question that I as a structural engineer worry about in terms of how safe is safe enough has really different answers depending upon what kind of environment, local, political, or natural hazard one is talking about, and from the Science Committee's perspective, I think the natural hazard differences are really of interest. We are not designing structures to resist earthquakes to be as safe as we are with respect to wind, snow, or any other natural hazard except flood. Flood is almost out in a different room, if you will, maybe in the same building, but our hazard level that we consider the design criterion for flood is something on the order of 100 or 200 years, mean recurrence interval. That means that within a given year, you have a one percent or one-half percent chance of your flood protection system failing. The current earthquake criterion is a one out of 5,000 chance per year. For a wind load failure on a structure that meets the building code, it is more like one out of 125,000 to one out of 50,000 chance per year. This is a public policy question that engineers alone shouldn't necessarily be answering. And if there's something that I would like to see a multi-hazard approach taken on. It is—what are the appropriate safety levels?

Dr. LINDELL. I would like to return to this issue of multi-disciplinary research because it is one that the NRC Committee on Disaster Research in the Social Sciences addressed at some length. One of the things I would like to remind you is that as a rule, universities award degrees in disciplines, not in problems. Earthquake hazard mitigation, like other hazard mitigation, is a problem, not a discipline.

And so it is really—part of the problem is to figure out ways in which to get universities—and the research faculty in those universities—to collaborate in trying to address these problems. A consequence of the fact that we are trained in disciplines is that we view the world very much like a very famous *New Yorker* cover in

which it shows a view from Manhattan, and Manhattan island takes up one half of the cover, and then New Jersey and Pennsylvania take about the next quarter, and then on the distant horizon are California and Japan. That is the way that every discipline trains its members to view the world. We look at very fine distinctions within our disciplines and think they are very large. And so what happens as a consequence is that social scientists are trained to think of physical scientists and engineers are pretty much interchangeable, and that physical scientists and engineers see the different social sciences—psychology, economics, sociology, political science—as all the same. Of course, this is horrifying to anybody within those disciplines. The problem is that universities need to create incentives to get people out of their own disciplines simply because all the rewards are to doing things within your own discipline.

NSF had a brilliant idea a number of years ago to require in some programs that submission of proposals required that there would be at least one physical scientist or engineer and one social scientist as a key member of the project staff. That requirement had a huge influence on people's willingness to engage in interdisciplinary research. It is as a philosopher once said, a journey of 1,000 miles but are only at the very first steps. There are some engineers that are further along than others. There are some social scientists that are further along than others. But those kinds of incentives are definitely effective in improving the amount of multidisciplinary research.

Prof. O'ROURKE. Chairman Wu, there is a well-known person in our community, that is, the natural hazards and earthquake community, by the name of Dennis Mileti who says that natural hazards never went to college, they never had to major in any particular area of engineering or science. And I think that sort of speaks to the way that communities look at natural hazards. If they are affected by earthquakes, they are very seriously affected and concerned. If they are affected by hurricanes, it is similar for that particular hazard. In other words, if I could give one more quote, that would be from Voltaire, "We are all victims of our virtue but there is no virtue in being a victim." What we want to do is to protect our communities, and perhaps the best way to do that is to find a multi-hazard approach. However, natural hazards, R&D, and coordinated hazards research involves science, modeling and engineering. It really does differ among the hazards, and so they do have to be approached on a technological basis differently, and it also involves a lot of institutional cultures and stakeholders and a multitude of governmental agencies. And that is why, I think, a very good way to approach this on a broad level and a level that would help to integrate it is to pursue the National Academies in trying to put together an NRC study that would bring together all the stakeholders and look at this problem from an integrated perspective and give us the time to reflect and understand how to go forward and in that process to recognize that NEHRP is really the gem within the programs that address natural hazards. The wonderful things that have come from this program, and the reduction in risk that it has been able to generate for communities affected by seismic and tsunami hazards, has been extraordinary

but also the fact that it has generated so much technology, so much procedure, and so much policy which is shared and used by the other natural hazards. You know, one of the great examples is the World Trade Center disaster. When the World Trade Center disaster occurred, the buildings surrounding the World Trade Center site had to be inspected, but there was no existing protocol for how to examine a building next to a terrorist attack. But they used protocols from inspecting buildings for earthquakes and adapted it, and that allowed some very important trading companies to participate in the market much more quickly than they would have and helped really to establish financial order worldwide.

So supporting NEHRP is also an important part of this, and I hope we can perhaps increase some of the authorized levels modestly but certainly try to achieve in our enactment the authorized levels to use this program as the cornerstone for going forward in multi-hazards.

Chair WU. Thank you, Professor O'Rourke. Mr. Murphy, please.

Mr. MURPHY. Thank you, Mr. Chair. From the emergency management community, we are interested in using things like NEHRP and different programs to look at things from a multi-hazard viewpoint, but I also don't want us to lose focus on the specific subject of earthquake. I think it is unique, even though we have things like Northridge or the Nisqually Earthquake in Washington State or in 2011, I believe, we will be doing a new Madrid exercise for the Central United States. I still think there is much to be learned. I do think we have to narrow our focus sometimes, even though there are commonalities. I would never deny that. But I do think we need to focus it. At least from the emergency management community, we can use all the science tools and the technology, you know, to help us out. I think about tools and technologies that have been developed over time for tornadoes or hurricanes or different events, you know. I think those are helpful, and I hope that the reauthorization of this program will induce us to keep moving forward because I really do need those tools and that research, and even the money for public education and outreach. That will make us stronger as a nation. Thank you.

Chair WU. Thank you very much, Mr. Murphy. Dr. Hayes.

Dr. HAYES. Looks like I'm nominated to speak again. I thought about what I might say, and it is not profound, but I think it is important. One of the reasons that I took the job that I took three years ago was that the earthquake community is probably the most dedicated professional community I have ever witnessed anywhere. And as you consider the issue of multi-hazard and what might be done in relation to other hazards and looking at the example of NEHRP, don't overlook the fact that part of NEHRP's success, in fact a large part of it, has been the involvement of dedicated people from the private sector from academia, State and local governments, the dollars that we talk about for NEHRP have been leveraged in ways that no one has ever been able to document because of the dedicated service that people such as the gentlemen at the table today with me have provided for the program. They have done it not because of NEHRP but because they think it is the right thing for the Nation. That is something that you can't put a price tag on, and it is really important to consider that as we look

at other hazards to see what kinds of communities might exist in relation to those other hazards as well. Thank you very much.

Chair WU. Thank you very much. I want to thank the entire panel and thank you for appearing before the Committee and the travel that many of you have done. The record will remain open for two weeks for additional statements from the Members and for answers to any follow-up questions that the Committee may ask of the witnesses. Again, thank you all very, very much for this thoughtful discussion. The witnesses are excused, and the hearing is now adjourned.

[Whereupon, at 12:00 p.m., the Subcommittee was adjourned.]

Appendix:

ANSWERS TO POST-HEARING QUESTIONS

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ANSWERS TO POST-HEARING QUESTIONS

Responses by John R. Hayes, Jr., Director, National Earthquake Hazards Reduction Program (NEHRP), National Institute of Standards and Technology (NIST), U.S. Department of Commerce

Questions submitted by Chair David Wu

Q1. Please provide the Committee with the fiscal year (FY) 2010 National Earthquake Hazards Reduction Program (NEHRP) budget requests for the National Institute of Standards and Technology (NIST), Federal Emergency Management Agency (FEMA), U.S. Geological Survey, and the National Science Foundation. Please include a list of programmatic activities that will be supported by these funds.

A1. With the adoption of the new NEHRP Strategic Plan,[1] NEHRP is tracking agency funding by the Strategic Goals as they are listed in the Plan. The relationships of the Strategic Goals to the Program Activities that are listed in P.L. 108–360 is as follows:

NEHRP Strategic Goal	NEHRP Program Activities (as defined in PL 108-360)
Goal A: Improve Understanding of Earthquake Processes and impacts.	Improve the understanding of earthquakes and their effects on communities, buildings, and lifelines, through interdisciplinary research that involves engineering, natural sciences, and social, economic, and decision sciences.
Goal B: Develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society-at-large.	Develop effective measures for earthquake hazards reduction.
Goal C: Improve the earthquake resilience of communities nationwide.	Promote the adoption of earthquake hazards reduction measures by federal, state, and local governments, and others.
Develop, operate, and maintain NEHRP facilities (ANSS-USGS, NEES-NSF, GSN-NSF/USGS).	Develop, operate, and maintain ANSS, NEES, and the GSN.

The requested FY 2010 NEHRP agency budgets, listed by Strategic Goal, are:

Strategic Goal	Funds Allocated to Goal ($M)				
	FEMA	NIST	NSF	USGS	Total
Goal A	0.1	0.2	31.5	11.4	**43.2**
Goal B	3.3	3.4		31.6	**38.3**
Goal C	5.7	0.5		4.2	**10.4**
Develop, Operate, & Maintain NEHRP Facilities			25.5	14.3	**39.8**
Total:	**9.1**	**4.1**	**57.0**	**61.5**	**131.7**

Q2. In Dr. Harris' testimony he stated that an "opportunity for improvement" for NEHRP existed in "deepen[ing] the commitment of DHS to NEHRP." At the previous reauthorization hearing for NEHRP in 2003, then Director of the FEMA Mitigation Division, Mr. Anthony Lowe, stated that increasing the interaction between NEHRP and the Department of Homeland Security Science and Technology (DHS S&T) was a high priority. Why hasn't there been improvement in the level of coordination and interaction? Please provide some examples of where NEHRP has collaborated with DHS S&T.

A2. Since the creation of DHS in 2003, the FEMA Mitigation Directorate (NEHRP) has coordinated and interacted with DHS Science and Technology (S&T) when opportunities to address all hazards issues have presented themselves. The most significant example of this coordination has been FEMA's *Risk Management Series* (RMS), a collection of over 20 publications, training materials and assessment tools. The objective of the RMS series is to provide guidance in the post 9/11 environment on managing risks from different hazards in a balanced manner, resulting in re-

[1] *Strategic Plan for the National Earthquake Hazards Reduction Program, Fiscal Years 2009–2013,* October 2008.

duced physical damage to buildings, injuries and/or loss of life. Different natural hazards (such as earthquakes, floods, high winds) and man-made hazards (such as conventional bombs, chemical, biological, and radiological (CBR) agents) are addressed in these publications.

FEMA Mitigation (NEHRP) continues to reach out to DHS S&T to keep this material current with research and knowledge. While interactions have not been extensive, FEMA NEHRP continues to seek opportunities to coordinate with DHS S&T.

Q3. Both ATC–57, The Missing Piece: Improving Seismic Design and Construction Practices, *and previous NEHRP testimony before the Science Committee in 2003 discussed the need to address the growing gap between the science and engineering knowledge generated by NEHRP and its application. NEHRP testimony on June 11 of this year described activities such as technical support for the code development process, developing tools to improve earthquake engineering practice, and techbriefs to familiarize practicing engineers with new concepts in seismic design.*

Q3a. What proportion of total NEHRP funding supports these applied activities? To what degree is this level of support commensurate with closing this gap? Please also provide specific examples which illustrate the success of the activities identified above in closing this gap.

A3a. Both FEMA and NIST directly support applied activities that focus on "closing the gap." In the FY 2009 NEHRP budget, most FEMA and NIST projects that contribute to Goals B and C of the Strategic Plan are directly tied to these applied activities. The total is about $12M, approximately nine percent of the total NEHRP budget. The 2009 percentage is up from about six to seven percent of the total in recent years, reflecting renewed support for NEHRP activities in those agencies.

While the question raised seems to point specifically to the engineering activities of FEMA and NIST, it is important to note that USGS supports or performs a significant amount of applied activity. Approximately a third of the USGS Earthquake Hazards Program funding is applied to developing hazard and risk products that are heavily used by engineers, planners, and emergency managers, as well as directly by the public. This funding supports development of seismic hazard assessments at national, regional and urban scales. In one of the flagship efforts for NEHRP, the National Seismic Hazard Maps are translated into the seismic provisions of model building codes through the involvement of FEMA and the consensus process of the code development community. Regional hazard maps like the recent California statewide earthquake rupture forecast are directly applied to insurance rate-setting and other purposes. Urban seismic hazard maps like those released this past year for Seattle provide much greater detail than the national or regional maps, include site effects due to soil type and other key factors. The Seattle maps are being used by the City of Seattle to prioritize retrofits and for the design process of new highway and bridge construction.

As mentioned in the NEHRP Strategic Plan, the NEHRP agencies identified nine strategic priorities for the Program that will receive increased emphasis, contingent on available resources. All nine strategic priorities are closely tied to applied activities that would accelerate "closing the gap."

FEMA has been active in this area for 30+ years, producing over 200 earthquake design guidance publications on all aspects of earthquake mitigation and conducting or supporting related outreach and training activities. FEMA's development, publication, dissemination, and promotion of building design and construction materials are signature examples of NEHRP applied activities. Following are some examples of FEMA's successes:

- FEMA first developed *The NEHRP Recommended Provisions for New Buildings and Other Structures* ongoing series of publications in 1985 and has been periodically updated them since. This series is a primary resource for translating NEHRP and other research results into design practice and implementation, with the primary goal of improving the Nation's consensus standards and model building codes. FEMA works through the Building Seismic Safety Council (BSSC) to involve the Nation's leading earthquake engineering practitioners and researchers in developing the "*Recommended Provisions.*" The latest addition to this series is the pending 2009 *NEHRP Recommended Provisions,* which contains many consensus-approved changes to the national design consensus standard, ASCE 7.[2] Probably the most significant change is the adoption of new seismic design maps based on the 2008 USGS seismic

[2] *Minimum Design Loads for Buildings and Other Structures,* ASCE/SEI 7–05, American Society of Civil Engineers, 2006.

hazard maps. The changes contained in the 2009 *NEHRP Recommended Provisions* are serving as the basis for changes currently being balloted for the 2010 edition of the ASCE 7 standard, which will then adopted by reference by the 2012 *International Building Code* (IBC).

- It is also noteworthy that FEMA's efforts in this area contributed significantly to a national movement away from three regionalized model building codes into the nationally-recognized IBC. Via the Building Seismic Safety Council (BSSC), FEMA supports a group of experts who submit changes developed under the *NEHRP Recommended Provisions* and other projects to the IBC and other "International Codes" series documents (published by the International Code Council). The International Codes, as well as the three predecessor codes, have been substantially equivalent to the *NEHRP Recommended Provisions* for over 15 years. The International Codes series serves as the basis for State and/or local building codes in all 50 states.
- Existing buildings are potentially greater risks than new buildings, since most were constructed prior to the adoption of current building codes; many could be collapse hazards. FEMA has developed and published a series of technical design guides on seismic evaluation and retrofit of existing buildings. Publications include *Rapid Visual Screening for Potential Seismic Hazards* (FEMA 154) for assessing large populations of buildings, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (FEMA 356) for retrofitting existing buildings, to *Techniques for the Seismic Rehabilitation of Existing Buildings* (FEMA 547), which is a publication developed with NIST assistance that provides retrofit guidance techniques based on building type. Information from these publications served as the basis for the national consensus standard for seismic evaluation of existing buildings, ASCE 31,[3] and the national consensus standard for seismic protection of existing buildings, ASCE 41.[4] These standards in turn serve as the basis for the *International Existing Buildings Code* (IEBC), part of the International Codes series.
- A primary recent FEMA focus is the development of Performance Based Seismic Design (PBSD) guidance and other materials for new and existing buildings. When mature, PBSD will enable evaluating how an entire building is likely to perform in a given earthquake and permit design of new buildings or upgrade of existing buildings with a realistic understanding of the risk of casualties, occupancy interruption, and economic loss that may occur as a result of future earthquakes. FEMA currently supports a multi-year project to develop Performance Assessment Methodology and Guidelines for new and existing buildings—the 50 percent draft *Guidelines for Seismic Performance Assessment of Buildings* and an accompanying *Performance Assessment Calculation Tool* (PACT) are currently under review by FEMA. The second phase of this project will develop a series of PBSD Guidelines for use with different structural systems and building occupancies.
- In addition to PBSD work, FEMA supports efforts to improve the prescriptive seismic provisions of ASCE 7 and the IBC, thus improving the performance of buildings designed with these model codes. It has recently supported the development of a new methodology through the Applied Technology Council for reliably quantifying building system performance and response parameters; these parameters are critical components of the prescriptive building code seismic design process. To report on this new methodology, FEMA will soon publish the *Quantification of Building Seismic Performance Design Factors* (FEMA P–695).

As NIST restarts its active applied research efforts with increased funding, it is working very closely with FEMA. NIST received an increase of $800K in NEHRP funding (for a total of $1.7M) in FY 2007 and an additional NEHRP funding increase of $2.4M in FY 2009 (for a total of $4.1M) providing funding for the applied activities that were outlined in ATC 57. Requested NIST funding for FY 2010 would continue support for these applied activities. NIST is committed to a combined in-house and extramural work accomplishment approach that was suggested by ATC 57. To that end, NIST awarded a multi-year Indefinite Delivery, Indefinite Quantity research contract in 2007 and is now in the process of developing a new in-house earthquake engineering work force. Also consistent with the ATC 57 recommenda-

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[3] *Seismic Evaluation of Existing Buildings*, ASCE/SEI 31–03, American Society of Civil Engineers, 2003.

[4] *Seismic Rehabilitation of Existing Buildings*, ASCE/SEI 41–06, American Society of Civil Engineers, 2007.

tions, NIST has structured its NEHRP research program to address performance-based engineering, building code development technical support, national design guidelines, and evaluated technology dissemination.

NIST is currently supporting beta testing of the FEMA P–695 methodology. NIST is in the process of awarding new task orders on its research contract that will contribute to both PBSD and to improved model building code provisions. NIST has recently released two techbriefs, *Seismic Design of Reinforced Concrete Special Moment Frames* (NIST GCR 8–917–1) and *Seismic Design of Steel Special Moment Frames* (NIST GCR 09–917–3).

Q3b. Is there similar support for applied activities in the social sciences?

A3b. Several of the NEHRP agencies are involved in this area.

NSF is responsible for a significant portion of the NEHRP social sciences activities. In general, knowledge transfer and dissemination mechanisms in the social sciences are different from those in engineering and the physical sciences. NSF supports the activities of the Natural Hazards Center at the University of Colorado, Boulder, which serves as a major clearinghouse that links the research and practitioner communities. This center provides information on research results for over 20,000 subscribers. With the assistance of other NEHRP agencies, such as FEMA and USGS, total annual funding for the center is about $750,000. Various other major research centers across the country, such as the Disaster Research Center at the University of Delaware and the Hazard Reduction & Recovery Center at Texas A&M, engage in knowledge transfer and training programs. These centers also receive NSF funding.

A portion of FEMA's earthquake work addresses social science issues. Most of this work focuses on outreach activities targeting the general public. The goal of these outreach activities is to affect behavioral change that improves public awareness, encourages appropriate response, and promotes activities to reduce future losses.

As part of this outreach, in 2008, FEMA initiated *QuakeSmart,* a program to encourage business leaders and owners in areas at risk from earthquakes to take actions to mitigate potential damage to their businesses, provide greater safety for customers and employees, and speed post-earthquake recovery. Businesses that participate in the program benefit in numerous ways: their investments are protected better; they can recover more quickly from a disaster; they can save on insurance premiums; they can significantly reduce the risk of injury or death for themselves, their employees, and customers; and they create a more resilient community in which future investment is more attractive. *QuakeSmart* started with community forums in four cities in the Midwest and on the West Coast. Two regional follow-up events are planned for late 2009. Overall, FEMA has dedicated approximately $600,000 over the last two years to *QuakeSmart.*

Other FEMA outreach efforts include the development and ongoing distribution of outreach-related FEMA publications, including: *Promoting Seismic Safety: Guidance for Advocates* (FEMA 474), *Earthquake Safety Checklist* (FEMA 526), *Earthquake Safety Activities for Children and Teachers* (FEMA 527), *Earthquake Home Hazard Hunt Poster* (FEMA 528), *Drop, Cover and Hold Poster* (FEMA 529), *Earthquake Safety Guide for Homeowners* (FEMA 530), and *The Adventures of Terry the Turtle and Gracie the Wonder Dog* (FEMA 531). The cost of developing, printing and the ongoing distribution of these publications since 2003 exceeds $500,000.

The USGS has worked closely with social scientists, both within the agency and in the university community, to develop effective outreach activities and products. A recent example is the Great Southern California *ShakeOut.* USGS and its partners developed a scenario of the likely effects from a magnitude-7.8 earthquake on the Southern San Andreas Fault, which required not only expertise on the shaking and other hazard effects but also a wide range of expertise on the societal impacts, including economic losses, disrupted commuting patterns, and school impacts. Social scientists played a key role in the *ShakeOut* exercise, which was the largest public preparedness event in U.S. history, involving over five million people. The messages for the *ShakeOut* were developed using the results of extensive social science research into what is most effective. Social scientists have played key roles in scenarios developed for other high-hazard cities as well as helping to guide development of preparedness materials for maximum effect.

Q4. Dr. Lindell noted in his testimony that research was needed to design better methods to encourage the adoption of mitigation measures. This need was also cited by NEHRP testimony before the Science Committee in 2003. What has NEHRP done specifically to address this since 2003? How much NEHRP funding, in general, has supported social science research since the last reauthorization?

A4. NSF supports social science research on earthquakes and other hazards. Since 2006, that support has totaled over $50M. The NSF-wide Human and Social Dynamics solicitation contributed over $34M for research on hazards and disasters, and the Directorate for Engineering's Infrastructure Management and Extreme Events program contributed over $14M. These research grants all include plans for technology transfer and dissemination of research findings. Increasingly, they are utilizing the Internet and other technologies to augment the traditional mechanisms of publications on professional journals, research reports, and after action reports. NSF has funded research on the adoption of mitigation measures by households and communities.

Q5. The 2006 National Research Council (NRC) report referenced in Dr. Lindell's testimony recommended creating a Panel on Hazards and Disaster Informatics. Should this be a NEHRP responsibility? How should the challenge of sharing and standardizing hazards-related social science data be addressed?

A5. NSF funded the development of the NRC report that recommended creating a Panel on Hazards and Disaster Informatics. This recommendation was one of many in the report. As recommended, this non-governmental Panel would have a two-fold mission: to assess issues of data standardization, data management and archiving, and data sharing as they relate to hazards and disasters, and to develop a formal plan for resolving these issues to every extent possible within a decade.

The recommendations did not suggest an organizational framework for the panel. The NEHRP agencies envision the proposed Panel would be formed under the aegis of the NRC and would be *ad hoc* in nature, with the purpose of developing the proposed plan. If sufficient resources can be identified, the NEHRP agencies are willing to take the leadership in pursuing the development and support of this Panel; however, for it to be effective it must involve the support and participation of all other Federal agencies involved in disaster research, warning, and response. These include the Department of Homeland Security, the National Oceanic and Atmospheric Administration, the Forest Service, the U.S. Army Corps of Engineers, and many others. Without government-wide participation and support, the acceptance and applicability of the Panel results may be limited.

In developing a plan, the Panel will face challenges. Currently, no single institution has the authority or capability to data mine research findings and disseminate them to potential users. It is a matter of debate how such an institution should be organized. Some researchers favor a clearinghouse, some want to borrow the structure and function of the agricultural extension service that is supported by USDA and the states, and others want a panel. It is not clear how such an institution should be funded, how it should disseminate recommendations, or how it will legitimize its operation.

The centralization and standardization of hazards-related social science data has always been extremely difficult, given the great variety of qualitative and quantitative data that are gathered. Furthermore, there is an extraordinary variety of research designs, ranging from survey research, experimental and quasi-experimental investigations, ethnographies and ethnomethodologies, secondary data analysis, and participant observation studies. These designs may be perfectly appropriate for undertaking specific research projects; however they result in quite divergent forms of data.

NEHRP agencies have made some progress in addressing this issue. The Earthquake Engineering Research Institute (EERI), as part of its NSF-supported *Learning From Earthquakes* program, has made some progress in standardizing data collection from its reconnaissance teams. The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) provides a national data repository for earthquake engineering experimental data. However, this effort primarily involves the collection of standardized structural engineering, geotechnical engineering, and tsunami hazard test data. The National Earthquake Information Center (NEIC) of the USGS maintains an accessible archive of summary information on casualties and losses for major earthquakes. At least from the earthquake perspective, standardizing both social sciences and other data will be an essential part of the effort required to develop the Post-Earthquake Information Management System (PIMS) that is referenced in Question 6 (following).

Q6. The Advisory Committee on Earthquake Hazards Reduction recommended that NIST serve as "the single point of coordination" for all post-earthquake reconnaissance activities. What resources and authorities would NIST need to serve in this role? The NEHRP Strategic Plan also calls for the development of a National Post-Earthquake Information Management System. Who would be respon-

sible for operating and maintaining this system? What would the activities of operating and maintaining this system include?

A6. The NEHRP agencies are evaluating this significant new recommendation from the Advisory Committee. NIST is now comprehensively assessing the resources and authorities that it would need to serve in the lead agency role for post-earthquake reconnaissance. Regardless of the designated lead agency, post-earthquake reconnaissance, and the associated resource needs, will involve all of the NEHRP agencies.

The NEHRP strategic priority of establishing PIMS is also a very recent development. The NEHRP agencies believe that PIMS is vitally needed. NEHRP took a first step towards developing a concept for PIMS through a scoping study that FEMA supported in 2008.[5] This report, which may be downloaded in electronic form,[6] provides valuable first-step information, but additional study is needed to establish the requirements for this system—hardware, software, data collection criteria and formats for PIMS. The NEHRP agencies will work to develop the detailed planning needed to implement the PIMS concept.

Q7. The NEHRP Strategic Plan states that it will reestablish a dedicated State earthquake program, "subject to the availability of funding."

Q7a. In the absence of a dedicated program, what has NEHRP done to address this need since 2003?

A7a. As FEMA reported in 2003, FEMA's original NEHRP Earthquake State Grant Program was combined with other similar State grant programs into a single Emergency Management Preparedness Grant (EMPG) program in the late 1990's to give states more flexibility in addressing their hazards. Within the EMPG program, the NEHRP funding lost its programmatic identity over time and the viability of a number of the State earthquake programs began to suffer as states used funds for other hazards. Since that time, virtually every state that had previously received NEHRP Earthquake State Grants has suffered significant reductions in support and capacity; many of the earthquake-related activities had been curtained or stopped altogether. The net result was a significant reduction in State-level capabilities to prepare and respond effectively to a major earthquake event.

Under the *NEHRP Reauthorization Act of 2004* (Public Law 108–360), FEMA was directed to undertake a number of activities, including operating a program of assistance to states to accomplish various eligible earthquake mitigation activities. This new State Earthquake Assistance Program will support that responsibility by providing assistance to accomplish the following eligible activities:

- Develop seismic mitigation plans,
- Prepare inventories and conduct seismic safety inspections of critical structures and lifelines,
- Update building codes, zoning and ordinances to enhance seismic safety,
- Increase earthquake awareness and education, and
- Encourage the use of multi-State groups for such purposes.

In FY 2009, FEMA re-established a State Earthquake Assistance Program. In the mid-1990's, when the NEHRP Earthquake State Grant Program was subsumed into EMPG, the grant funding level was approximately $4.5M. In FY 2009, FEMA is committing $2.3M to this new program. When adjusted for inflation, the new program is less than half of the previous funding. However, it is an important step in supporting states to begin re-building their earthquake programs.

Under this new State Earthquake Assistance Program, FEMA plans to enter into cooperative agreements with as many as 29 states and territories. This $2.3M program will support enhancing and maintaining State earthquake hazard mitigation programs for planning, education and assessment activities. By supporting and improving State earthquake programs, FEMA will be helping to reduce the loss of life and property from future damaging earthquakes.

The criterion for eligibility for State assistance is demonstrating that the assistance will result in enhanced seismic safety in the state. Other goals include establishing and/or maintaining a dedicated State Earthquake Hazards Reduction Program and achieving measurable improvements in earthquake mitigation activities. Funded activities will be determined through individual negotiations between FEMA and the states.

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[5] *Post-Earthquake Information Systems (PIMS) Scoping Study,* American Lifelines Alliance, September 2008.

[6] *http://www.americanlifelinesalliance.org/PIMS%20Report/PIMS.Final%20report.pdf*

Q7b. Also, according to a 2004 Government Accountability Office assessment of the FY 2003 FEMA Pre-Disaster Mitigation Program, only seven percent of the grants applied for were related to seismic hazard mitigation. What factors accounted for this comparatively low level of attention to seismic risks?

A7b. The table below provides updated data for the FEMA PDM program from fiscal years 2003 to present:

PDM SEISMIC PROJECTS						
Year	Seismic Projects Submitted	All Projects Submitted	% Seismic Submitted	Seismic Projects Eligible	All Projects Eligible	% Seismic Eligible*
2003	19	313	6.1%	8	147	5.4%
2004/2005	82	424	19.3%	62	277	22.4%
2006	19	116	16.4%	14	65	21.5%
2007	39	254	15.4%	21	117	17.9%
2008	41	249	16.5%	23	121	19.0%
2009	34	246	13.8%	21	93	22.6%

*"Eligible" indicates those projects that met established program criteria.

The percentage of seismic projects submitted compared to the total number of projects submitted has improved substantially since the inception of the Program. Overall, seismic projects are well developed, feasible, and effective from engineering and cost perspectives. However, there are several reasons why there are fewer seismic projects submitted than other hazard types (i.e., flood and wind):

- Not all states have a substantial seismic risk.
- States may not appropriately identify seismic risk (i.e., states in the New Madrid Fault Zone).
- States prioritize their sub-applications for submittal to FEMA in accordance with the risks identified in their respective State and local Multi-Hazard Mitigation Plans.
- Since seismic retrofit projects tend to be more expensive than those for other hazards, and the PDM program does not include multi-year funding, this may tend to discourage states from submitting these types of projects.
- PDM program appropriations fluctuate from year to year. And,
- There are competing requirements for funding (i.e., State Set-Aside (Stafford Act Requirement and Congressional Earmarks).

ANSWERS TO POST-HEARING QUESTIONS

Responses by Kenneth D. Murphy, Immediate Past President, National Emergency Management Association (NEMA); Director, Oregon Office of Emergency Management

Questions submitted by Chair David Wu

Q1. The National Earthquake Hazards Reduction Program's Strategic Plan states it will re-establish a dedicated State earthquake mitigation program "subject to the availability of funds."

Q1a. What has been the impact of a lack of federal funding for this program?

A1a. The impact of a lack of federal funding effects each states plan for a well coordinated and consistent earthquake hazards program. Many states do not have any dedicated funding of their own and truly depend upon the NEHRP program. The federal funding for states provides many opportunities that we cannot afford in the earthquake hazards environment. One of the most difficult challenges is trying to convince elected leaders at any level of government or business leaders in the private sector to make these investments before the disaster strikes and a disaster they may not have ever happened to them or very infrequently. I believe the lack of funding simply hurts the states and the Nation's ability to have a consistent mitigation, preparedness, response, and recovery program for earthquake hazards, you find yourself going at one pace, then you have to slow down or speed up based upon funding or just not continue. The lack of funds had the biggest impact on the states to maintain outreach and public education to its citizens and visitors, as you know this type of activity must be on-going, especially dealing with preparedness activities.

The lack of funding also hurts the states in their ability to get more localized and specific types of information or scientific data to help them plan, make decisions, and transfer research into cost-effective mitigation strategies. Finally the lack of funds also hinders states from implementing pilot projects for mitigation, development and implementation of immediate and long-term recovery plans. The lack of funding also has impacted states abilities to collaborate on multi-State projects.

The NEHRP program is critical to this nation's ability to deal with earthquakes. Over the last half century we have enough experience and data based upon actual earthquakes in the United States and around the world that clearly should give us pause as to are lack of preparedness.

Q1b. In 2004, the Government Accountability Office reported that only seven percent of the fiscal year 2003 Federal Emergency Management Agency Pre-Disaster Mitigation grant applications were for earthquake mitigation. In your opinion, what were factors in this low utilization of available funds?

A1b. The Pre-Disaster mitigation grant program (PDM) is a very valuable program to states for mitigation activities. I cannot characterize any specifics about states low use of funds without some further research. My perspective from Oregon is that using these PDM funds for earthquake mitigation is hampered by the large dollar totals a State specific mitigation project may cost for earthquake projects, these high dollar projects will take most of your PDM dollars and states may have decided to go with lower cost projects. Additionally, it depends upon the state's overall mitigation plan, which may have many varying mitigation focuses and certain states have chosen to use this money for other more frequent hazard mitigation projects such as flood control.

It is also a possibility that states may not have had applicants ready or eligible for these types of earthquake mitigation projects.

Q2. One of the activities discussed in the Strategic Plan is the continued development and use of earthquake scenarios. How do State officials, such as emergency managers, use these tools? How could they be more effective?

A2. These types of products which are constructed by professional individuals and organizations provide a great tool for emergency managers. These types of tools if consistently improved based upon science or experience do help emergency managers. It takes the burden off of emergency managers to develop these scenarios and allows more time to exercise or plan for results based upon the scenarios.

I believe they can be most effective if the scenarios are accurate representations of your jurisdiction, they contain good data and known effects. Additionally, if the scenarios are built to address more than just the emergency management community, this would make them more effective.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Thomas D. O'Rourke, Thomas R. Briggs Professor of Engineering, School of Civil and Environmental Engineering, Cornell University

Questions submitted by Chair David Wu

Q1. In Dr. Harris' testimony he stated that an "opportunity for improvement" for the National Earthquake Hazards Reduction Program (NEHRP) existed in "deepen[ing] the commitment of DHS to NEHRP." Previous NEHRP testimony in 2003 noted that increasing the interaction between NEHRP and Department of Homeland Security (DHS) Science and Technology was a high priority. How would you assess the current interaction between NEHRP and other components of DHS? How could this interaction be strengthened?

A1. At FEMA, NEHRP staff has interacted with DHS in productive ways since the creation of DHS in 2003. A good example of this interaction is the production of the Risk Management Series (RMS), a collection of more than 20 different documents, training curricula, and vulnerability and assessment tools. The development and dissemination of these documents were funded with NEHRP and other FEMA Mitigation Directorate resources. The documents were focused on knowledge and information needed by architects, engineers and contractors to address human threats in the built environment that is owned and maintained by the private sector. After 9/11 it was recognized that essential information on dealing with human threats was not readily available to the private sector, even though guidance was at hand for designing and hardening military facilities, U.S. embassies, and other government buildings. The RMS documents have helped fill this knowledge gap and are being widely used. These documents have also resulted in opportunities to collaborate with the DHS Science and Technology Directorate, Office of Infrastructure Protection, and Policy Office.

Even though there are examples of successful programs, like the RMS documents, the overall DHS engagement of NEHRP within FEMA has been uneven. For example, FEMA was responsible for developing the national loss estimation procedures embodied in the software HAZUS. This program has been very successful for earthquakes, and has been adapted to floods and windstorms. When DHS was developing modeling capabilities for human threats, there was little interaction between DHS and FEMA, even though FEMA had acquired extensive experience in modeling the effects of natural hazards when producing HAZUS. Ultimately, DHS created its own tools without making use of the HAZUS tool set developed over 10+ years at a cost of $40M.

Programs within FEMA, which are focused on natural hazards, involve community interactions, dealing with multiple stakeholders, building consensus for standards and guidelines, and public education. In my opinion, the security of U.S. communities requires the ability to deal with sensitive and often subtle societal issues, as well as the ability to achieve security hardening against human threats under the leadership of managers with law enforcement and military experience. DHS could benefit substantially from the experience acquired by FEMA with communities vulnerable to natural hazards. There is perhaps no better illustration of the need for working with communities to achieve resilience than New Orleans before and after Hurricane Katrina. I was a member of the National Academies Committee on the New Orleans Regional Hurricane Protection Projects and saw first hand the need for better coordination with local communities and utility companies that are responsible for the lifeline networks. The social science and remote sensing expertise gained through NEHRP is providing support for building a more resilient New Orleans, and should receive greater attention and support from DHS.

An important way to promote productive and sustainable interactions between DHS and NEHRP is for NEHRP to appear as a line item in the DHS budget for FEMA. A line item in the budget would be the single most effective action to improve the visibility and accountability of the program.

Q2. What has been the result of the elimination of the American Lifelines Alliance by the Federal Emergency Management Agency (FEMA)?

A2. The elimination of the American Lifelines Alliance (ALA) has left NEHRP without a focused and dedicated program for the implementation of research findings and best practices for critical lifeline infrastructure, such as electric power, gas and liquid fuel delivery, telecommunications, transportation facilities, water supplies, and waste management systems. As indicated in my written testimony, the Advisory Committee on Earthquake Hazards Reduction (ACEHR) [2008] recommends

that all NEHRP agencies expand their activities related to lifeline systems, and points out that attention should be given to the interdependencies among lifeline systems as well as the national impact that a single outage can have.

When addressing lifelines, it is very important to enlist the assistance of the Technical Council for Lifeline Earthquake Engineering (TCLEE) of the American Society of Civil Engineers (ASCE). This volunteer, professional organization has a dramatic impact on reducing seismic risk to lifelines and has published many excellent reports and conference proceedings that are available through ASCE. This organization has received very little direct support through NEHRP and should figure more prominently in future NEHRP activities. Working directly with TCLEE should be a cornerstone for a NEHRP program focused on lifelines.

Q3. You mentioned FEMA State earthquake mitigation grants in your testimony. What were some of the successes of these grants? In the absence of a dedicated State earthquake mitigation program, what have states been unable to do? Do you believe there is a need to reinstate this program?

A3. The original FEMA State Earthquake Grant program supplemented State earthquake hazard mitigation program efforts and provided dedicated State funding for planning (response, mitigation, and preparedness), inspections of critical facilities, active support for building codes and land use issues, and staffing support to carry out these activities. There was also a matching funds requirement to ensure State commitment to the program. For a number of states these funds were the difference between having an EQ hazards reduction program and not having one.

As these funds and their visibility faded, beginning in the late 1990s with the creation of the Emergency Management Preparedness Grant (EMPG) program, State earthquake programs were compromised. By 2009, virtually every state, which had received grants previously, had suffered significant reductions in support and capacity, and many of the activities listed above had been curtained and stopped altogether. The net result is that there has been a significant, and perhaps profound, reduction in State-level capabilities to respond effectively to a major earthquake because of funding and staffing cut-backs. Along with the loss of resources and staff came a loss of expertise critical for effective earthquake response.

FEMA is now negotiating 29 cooperative agreements with 29 states (about $80,000 each) for an estimated $2.3 million for State earthquake hazard reduction programs. In the late 1990s, when the earthquake State grant program was subsumed into EMPG, the funding level was approximately $4.5M. Adjusted for inflation, the new effort is less than half that of the previous funding. However, it is an important step in the right direction.

The successful FEMA State Earthquake Grant program should be reinstated at levels that exceed those in the past to account for inflation and restore the balance and level of engagement that previously had been achieved. One focus of the State programs could be the seismic safety of schools, where there is substantial need for improvement. As indicated in my written testimony, a serious life safety threat exists with respect to non-ductile concrete, soft story, and unreinforced masonry buildings. Many schools fall within this these building categories, and steps should be taken to correct this situation. The FEMA State Earthquake Grant program can provide critical assistance to retrofit or reconstruct unsafe buildings and improve the safety of our schools.

Q4. With respect to getting civil infrastructure projects in place, you mentioned that there are "more effective ways of approaching" the dialogue between social scientists and engineers and scientists. Please assess current NEHRP activities in support of fostering the interaction between engineers and social scientists. What would you recommend to improve these interactions?

A4. As indicated in my written testimony, research into the social and behavioral aspects of community response to earthquakes is a natural complement to research that increases the resiliency of the built environment. Interdisciplinary research through NEHRP, which involved collaboration among social scientists, engineers, and geoscientists, has resulted in advanced technologies for reinforcing and monitoring the built environment, loss assessment methodologies, emergency response procedures, and a process for achieving disaster preparedness (EERI, 2008a). They also involve a unique, multidisciplinary culture that integrates basic and applied research into design codes, construction methods, and public policy. NEHRP-related interdisciplinary research has provided benefits that extend well beyond seismic risk to improve the security and economic well-being of U.S. citizens and other members of the world community within a multi-hazard context.

Effective programs involving interdisciplinary research have been supported in the past through NSF at the Earthquake Engineering Research Centers (EERCs).

Core funding for those centers has ended to make way for new NEHRP-related research. The interdisciplinary research at the EERCs provides good examples of successful programs that can guide interactive research with social scientists in the future. ACEHR (2008) recommends joint support from both NSF and NIST for multi-disciplinary projects either with the newly graduated EERCs or with teams that have the appropriate interdisciplinary skills. The Earthquake Engineering Research Institute (2008b) has issued a white paper, entitled *Earthquake Risk Reduction: Addressing the Unmet Challenges*, in which recommendations for an interdisciplinary research approach are provided. NSF is home for the Engineering, Geosciences, and Social, Behavioral, and Economic Sciences (SBE) Directorates. Hence, SBE is well positioned to develop multi-disciplinary projects involving social science interactions with the either the Directorates for Engineering or Geosciences, or both.

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ANSWERS TO POST-HEARING QUESTIONS

Responses by Michael K. Lindell, Professor, Landscape Architecture and Urban Planning; Senior Scholar, Hazard Reduction & Recovery Center, Texas A&M University

Questions submitted by Chair David Wu

Q1. In your testimony, you mentioned that more research was needed on how to design inducements to encourage people to adopt hazard mitigation measures. The 2003 National Earthquake Hazards Reduction Program (NEHRP) testimony before the Science Committee also noted the need to better understand and design such measures. What type of research is needed on this specifically? Why has progress lagged on this topic for the last six years of this reauthorization? What actions would you recommend to address this?

A1. The type of social science research that is most needed now is integrative research that systematically examines the effects of risk reduction programs involving different types of hazard adjustments. The term *hazard adjustments* encompasses all three types of hazard reduction actions—1) hazard mitigation, 2) emergency response preparedness, and 3) disaster recovery preparedness. Hazard mitigation comprises actions that provide passive protection when disaster strikes (e.g., better land use regulations and building codes that prevent damage and casualties from happening in the first place) Emergency response preparedness supports an active response when disaster strikes (e.g., better response plans, procedures, and training that prepare responders to stabilize damaged buildings, fight fires, and treat the injured). Disaster recovery preparedness speeds the community's return to normal levels of psychological, social, economic, and political functioning (e.g., developing more effective hazard insurance programs so families can rebuild their homes).

As I indicated in my testimony, economic market mechanisms alone cannot solve the problem of seismic hazard adjustment because people do not respond to hazards in the ways that are necessary for markets to work efficiently and effectively. Political mechanisms alone cannot solve the problem of seismic hazard adjustment because the Federal Government (which ultimately pays for much of the cost of disaster response and recovery) lacks control over the most important mechanisms that produce hazard vulnerability—ineffective land use and building construction practices. Thus, an integrated set of private and public sector actions is needed by stakeholders at multiple levels (household/business, profession/industry, local government, State government, and Federal Government).

Existing social science research has identified individual elements of a systemic approach to seismic hazard adjustment, but these elements have only been studied in isolation. Consequently, we do not know if a program that assembled these individual elements would function in the way it was intended to work. This is the reason that systematic multi-disciplinary research should be conducted to develop and evaluate comprehensive programs for seismic hazard reduction. Such research might, for example, systematically examine the National Flood Insurance Program to identify ways in which a different combination of market mechanisms, government incentives and sanctions, and technical assistance could more effectively guide land developers, homeowners, and banks to reduce their hazard vulnerability. Such research should address the communication of information about risk and hazard adjustments, and the development and dissemination of new hazard adjustment technologies, as well as positive (financial incentives), negative (punishment for violations of regulations), and facilitative (providing the means for implementation such as specialized knowledge and equipment) inducements.

There are fundamental obstacles to implementing comprehensive hazard reduction programs because there is no single societal institution in the public or private sector that has sufficient administrative responsibility and technical capability for providing relevant social science research findings to those who need them. Such an institution could monitor current research findings, assess their suitability for field application, and establish standards for practice. The NEHRP partner agencies—FEMA, NIST, NSF and USGS—lack the administrative responsibility and, consequently, lack a staff of qualified social scientists available for performing this function.

The reason a specific institution is needed to promote dissemination of social science research findings is that seismic hazard reduction lacks market mechanisms of the type that exist, for example, in the health domain. There, pharmaceutical manufacturers, who expect to make a profit on the sale of their products, conduct clinical trials at their own expense to determine if their new drugs are safe and ef-

fective. After receiving approval from the Food and Drug Administration, the pharmaceutical manufacturer can take its product to market. As is the case with the clinical trials, the expense of product distribution is paid by the manufacturer in the expectation of making a profit. In sum, where salable products exist, market incentives can generate innovations and distribute these innovations to users without government intervention.

By contrast, social science research rarely produces products that can be sold for a profit so there is no market incentive to conduct the types of tests that are equivalent to clinical trials. Nor is there an incentive to disseminate research finding widely because researchers are rewarded mostly for publishing their results in scholarly journals. Because there are few rewards for anyone to disseminate potentially useful research findings, the transfer of social science technology to practical application tends to be slow and inconsistent. The ultimate consequence is that communities remain unnecessarily vulnerable to earthquakes and other natural hazards even though social science findings exist that could reduce this vulnerability.

Q2. The 2003 NEHRP testimony before the Science Committee stated that increasing the interaction between NEHRP and the other components of the Department of Homeland Security (DHS) was a high priority. The 2006 National Research Council report you discussed in your testimony also recommended increased coordination between the National Science Foundation (NSF) and DHS for social science research and development. In your opinion, what have been the impediments preventing the recommendations made in 2003 and 2006 from becoming a reality?

A2. I know from personal experience that NSF has collaborated with at least two other federal agencies (the Department of Transportation and the Department of Commerce/National Oceanographic and Atmospheric Administration) in developing and funding programs that involved social science research. I don't know of any similar collaborative programs at the Department of Homeland Security, but this might be because I have only had limited contact with that agency.

I know that collaboration requires parties to be both willing and able to coordinate their actions but, in the case of DHS, I don't know which of these is the more important factor. My experience with the agency suggests that DHS has an extremely strong emphasis on terrorism and, within that focus, on applied research in the physical, biological, and engineering sciences. This would be an impediment to collaboration on social science relevant to natural hazard reduction. I also gather that DHS has very few social scientists, which would affect the agency's ability to collaborate.

Q3. As noted in Dr. Harris' testimony, there is a gap between earthquake science, engineering knowledge, and research findings and the ability of practitioners to use this knowledge. Are there examples of a similar gap that exist within the social sciences? If so, where? What mechanisms exist to bring social science research findings into practice?

A3. As I noted in my response to the first question, there is a substantial gap between social science research findings and their application to earthquake hazard reduction. The gap exists because there is no institution with sufficient administrative responsibility and technical capability to promote the transfer of the administrative technologies developed through social science research. There are currently some institutions that address this need in a very limited way. For example, the Natural Hazards Center at the University of Colorado serves as an information clearinghouse. However, this center lacks the funding and staff to transfer social science technology at the scale at which it is needed. More generally, social science technology transfer is achieved by the (mostly pro bono) entrepreneurial activities of a very few researchers.

Q4. Under NSF funding, the National Earthquake Centers required engineers and physical scientists to partner with social scientists. How successful were these partnerships? What would you recommend to ensure that the knowledge and expertise of social scientists are well integrated into collaborative projects?

A4. As I noted in my written testimony, there have been some cases of social scientists collaborating successfully with engineers and physical scientists. As the Committee on Disaster Research in the Social Sciences concluded, the Earthquake Engineering Research Centers had a mixed record of success in fostering such collaboration. However, even this limited amount of collaboration only existed while the Earthquake Engineering Research Centers were funded by NSF. I know of no evidence to indicate that any significant level of collaboration has continued since the termination NSF funding to the Earthquake Engineering Research Centers. In-

deed, despite the tremendous opportunity for technical advances that the George A. Brown Network for Earthquake Engineering Simulation seems to provide for engineers, this facility presents even fewer opportunities for collaboration with social scientists than were available through the Earthquake Engineering Centers.

ANSWERS TO POST-HEARING QUESTIONS

Responses by James Robert Harris, President, J.R. Harris & Company, Structural Engineers

Questions submitted by Chair David Wu

Q1. In your testimony you stated that an "opportunity for improvement" for the National Earthquake Hazards Reduction Program (NEHRP) existed in "deepening the commitment of DHS to NEHRP." Why hasn't there been an improvement in the level of interaction? What opportunities exist to strengthen the interaction between NEHRP and other sectors of DHS?

A1. I'm not close enough to the inner working of DHS to know why there has not been an improvement, although I understand there are many competing demands upon DHS. I'm not a social scientist, but it does seem to be human nature to assign lower priority to hazards that are rare events, even though the consequences may be high. That said, I suggest that an improved accountability would strengthen the interaction. It should be possible to track the expenditures and compare with the budget. Refer to the 2008 report of the Advisory Committee on Earthquake Hazard Reduction, "Effectiveness of the National Earthquake Hazards Reduction Program," prepared for and available from NIST, in which the second recommendation regarding FEMA read "Fund FEMA at the authorized level *and assure funding is dedicated to earthquake risk reduction*" (emphasis added). The Advisory Committee was seriously concerned about the erosion of funds made available to NEHRP within FEMA. Some of this erosion is the result of inflation, but some of it is simply difficult to track. Congress should review the tools at its disposal, make a decision about how to increase the accountability and then review the effectiveness.

Q2. Hearing testimony strongly supported greater resources and a larger role for the National Institute of Standards and Technology. In your testimony you noted that NEHRP must recognize and acknowledge realities in the building industry that slow the adoption of the latest research into practice. How could NEHRP activities be improved to close the gap between the creation of new science and engineering knowledge and developing the tools to allow practitioners to utilize this information?

A2. Two activities are necessary to close the gap: NIST must carry out its role in support of applied research, and FEMA must continue to develop and maintain guideline documents that are the source material for standards and codes. Both of these activities require funding. In the case of FEMA it is a continuation of prior funding, which as I mentioned earlier has been eroded. In the case of NIST, the funding has never really been there: it was authorized in the 2004 Act, but inadequate funding was not appropriated.

There is a direct analogy between preparing legislation and preparing technical standards: the final language inevitably reflects compromises necessary to gain consensus. In the case of the technical standards a far higher degree of agreement is needed than a simply majority, and the process of resolving dissent is rigorous, but there is dissent. In many cases the dissent exists because the depth of knowledge is simply inadequate. The applied research component does not attract the attention of the National Science Foundation, but it is no less necessary. The Building Seismic Safety Council has routinely compiled a list of research needs each time they close the preparation of a new edition of the *NEHRP Recommended Provisions,* and it is instructive that the same items show up time after time. These research needs are precisely the type identified in the report ATC 57 "The Missing Piece: Improving Seismic Design and Construction Practices."

Q3. You noted that the American Society of Civil Engineers/Structural Engineering Institute 7 map for wind speed is supported by volunteer efforts, and consequently is not as user-friendly as similar standards for earthquakes. What role could the Federal Government play to address this problem?

A3. I have reviewed the proposed "*National Windstorm Impact Reduction Reauthorization Act of 2009*" (H.R. 2627) currently under consideration by the Congress. I believe the program described in that bill is an appropriate role for the Federal Government, and I further believe that the proposed program would make a significant improvement in the problems that I described with the effectiveness of our standard for engineering buildings and other structures to resist winds. Specifically there are duties assigned to NIST to ". . . support research and development to improve building codes, standards and practices . . ." and to cooperate with FEMA to ". . .

work closely with national standards and model building code organizations to promote the implementation of research results . . .” that will directly affect the problems that I described. The basic research at NSF and NOAA and the cooperating research at NASA, the Department of Transportation, and the Army Corps of Engineers are important, and my emphasis on the work at NIST and FEMA is because that work is directly relevant to the question.

It is important that the authorization be followed by appropriations of funds to carry out the new activities at the pertinent federal agencies.

Q4. You testified that in terms of floods, we are more tolerant of failure of flood protection mechanisms than of any other type of hazards. You also stated that making decisions on failure-level tolerances should not be left to engineers alone. What should the role of NEHRP be in increasing the level of public involvement in these types of decisions?

A4. I think the role that NEHRP should play in the solution of the flood problem is primarily one of example. NEHRP has been a very successful program, in no small part because the amount and duration of financial support has assembled a critical mass of expertise across the Nation. That critical mass has made possible the significant improvements in our understanding of various aspects of earthquake phenomena and of structural response to strong ground motions. These improvements in understanding have led to significant changes in the ways we design and construct to resist the effects of earthquakes, and more significant improvements are relatively close at hand. To a great extent the expertise required for other natural hazards is different. The communities interested in multiple hazards—building code officials, engineers of various disciplines, social scientists with expertise in natural disasters, builders, producers of construction products and materials—will naturally be involved, but the scientists and many of the research oriented engineers do not have interests that span multiple hazards, and that expertise is crucial to developing the critical mass to make significant advances.

I participated in a workshop last Friday (July 10) at the Technical University of Delft, in the Netherlands. The workshop assembled experts from the U.S. and the Netherlands to discuss how we each approach design of structures and infrastructure for various natural hazards, with an emphasis on flood. It is my perception that the establishment of design criteria for flood safety in this country has not advanced on a parallel with the development of criteria for earthquake, wind, snow, and so on. I was impressed by several aspects of the Dutch approach to flood safety in their country: their methodology for establishing protection goals is based upon very similar concepts to that used for other hazards, their target level of safety appears to be comparable to that for other natural hazards, and they routinely perform cost-benefit analyses to ground their decisions. It was also fascinating to hear them say that Katrina’s effect on the U.S. was a big wake up call for them—not that they need to change their desired level of safety, but they gained a deeper realization of how complex flood protection systems really are and that there are many diverse ways they can fail. At this point some believe their protection systems need improvement to really deliver their professed goals.

With respect to the involvement of the public in decisions about the level of safety, I don’t really foresee much feasibility for extensive discussion in the general public realm. This is where multi-hazard approaches do make sense to me. Technical experts in various fields, including economists and social scientists, need to be encouraged to examine safety across a broad range of hazards and risks. We who have technical expertise in one or two narrow fields too often are making decisions that really do require knowledge and input from broader constituencies. These decisions are typically endorsed by groups with those broader interests as matters progress from single-topic standards to model building codes to the adopted laws of states and cities, but adjusting the safety level is rarely done at these later stages. When such adjustments are made, they oftentimes actually go in what many experts would consider to be the wrong direction and are usually based upon very limited cost studies. Therefore, I do recommend that FEMA continue to support the Multi-hazard Mitigation Council of the National Institute of Building Sciences, and I encourage the National Science Foundation to find creative ways to build social science roles into natural hazards research programs. And finally, I want to endorse the recommendation made by Tom O’Rourke at the hearing: commission the National Research Council of the National Academies of Science and Engineering to study the question of multi-hazard approaches to mitigation of our risk.

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