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A Brief Review of NEHRP and the NIST Role in NEHRP

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Introduction

Chairman Bucshon, Ranking Member Lipinski and other Members of the Subcommittee, on behalf of Secretary of Commerce Penny Pritzker and the Department of Commerce, thank you for inviting me to testify on the current activities of the National Earthquake Hazards Reduction Program (NEHRP), and, specifically, on current contributions of the National Institute of Standards and Technology (NIST) to NEHRP.

My testimony briefly summarizes my perspective as NEHRP Director regarding the statutory four-agency NEHRP partnership that includes the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST) – my home agency, the National Science Foundation (NSF), and the U.S. Geological Survey (USGS). My testimony also briefly summarizes specific activities at NIST that are conducted in support of NEHRP. You will hear in more detail from my partners in the other NEHRP agencies about their ongoing activities.

In the slightly more than three years since I last testified, the U.S. has fortunately continued to experience a relatively quiet period of major seismic activity, though there has been a noteworthy increase in small to moderate earthquake activity in areas where large volumes of waste fluids are being injected in the ground. But, this year brings three milestone anniversaries of devastating U.S. earthquakes – the 1964 Alaska earthquake (50 years), the 1989 Loma Prieta earthquake (25 years), and the 1994 Northridge earthquake (20 years). Earthquake professionals are participating in commemorations of those events that serve as reminders of the devastation and lives lost that can and will occur, summarize progress that has been made in making our Nation safer, and remind us of the great need for us to do more that will make our Nation truly earthquake-resilient. As the seismology experts in USGS often remind us, the question of future major earthquake occurrence in the U.S. is not one of "if," but "when." And, since the last major U.S. earthquakes occurred, our Nation has continued to "urbanize," with more people concentrated in urban areas, which exposes higher portions of the population in earthquake-prone areas, built environment, and commercial activities to devastation from a single large earthquake or other disaster.

While the U.S. has not suffered widespread major earthquake damage in recent years, devastating earthquakes around the world hold significant lessons that can be used to inform our risk mitigation efforts.

The first significant lesson is that mitigation efforts, through such measures as improved building codes, make a significant difference in life safety, which has long been the primary purpose of earthquake-related provisions in U.S. building codes and standards. In 2010, the Haiti and Chile (Maule) earthquakes illustrated the effectiveness of modern building codes and sound construction practices. In Haiti, where such standards were minimal or non-existent, and construction quality was poor, tens of thousands were killed in the collapses of homes and other buildings. In Chile, with much more modern building codes and engineering practices that were

substantially based on U.S. model building codes and standards that have been substantially derived from NEHRP research and development, the loss of life, while still tragic, was far smaller (about 500) despite the fact that the Chile earthquake had a significantly higher magnitude than the Haiti earthquake.

A second lesson, one that is becoming better understood and appreciated, is that major earthquakes (and other natural disasters) that strike areas that are not yet fully prepared for them can have significant long-term deleterious economic impacts. Consider several brief examples:

- The 1995 earthquake that struck Kobe, Japan, severely damaged its major port facilities. What was once one of the world's busiest (top ten) ports, especially for containerized cargo has not regained its pre-earthquake significance almost 20 years later.

- The 2011 earthquake that struck Christchurch, New Zealand, which was "moderate" in terms of its magnitude, caused extensive devastation, much of which was due to older construction and to soil liquefaction. The Christchurch City Centre, or central business district (CBD), was so seriously damaged that it was cordoned off from public access for over two years, and much reconstruction remains to be done for the area to regain its prior vitality. Some estimates postulate that it may take 50 years for Christchurch to recover completely.

- The 2011 earthquake and resulting tsunami that struck Tohoku, Japan, caused tragic death and damage, with the devastation to a major nuclear power facility being the most long-lasting impact.

The "second lesson" shows that the need for local, and indeed national, *resilience*, the ability to recover in a timely manner from the occurrence of an earthquake or other hazard event, is vital. Moving to enhanced resilience goes well beyond the essential, but focused, measure of ensuring life safety in buildings and other locations. Efforts to improve resilience must consider serious cascading failures that will likely extend impacts well beyond immediate damage to individual facilities due to strong shaking. The long-term economic impacts of these tragedies can be crippling, primarily to local economies, but also extending nationally and internationally.

A third lesson is that assuming that we already "know it all" (everything we need to know to mitigate, respond, and recover) is the surest strategy for catastrophe. We still have much to learn about the earthquake hazards we face, as well as the engineering measures needed to minimize the risks from those hazards. Japan and New Zealand are international leaders in seismology and earthquake engineering – we in the U.S. cooperate with our counterparts in both countries, because we have much to learn from one another. Despite their advanced technical knowledge, leaders in both countries were taken aback by the amount of damage that occurred in the events mentioned above.

A fourth lesson that we saw locally in 2011 is that we can sometimes experience damaging earthquakes in areas where they are not taken seriously and for which preparations are therefore

minimal. The earthquake whose epicenter was near Mineral in central Virginia, is believed to be the largest to have struck the U.S. east of the Rockies since the beginning of the 20th century and was unquestionably felt by more people than any previous earthquake in U.S. history. Various damage estimates for the earthquake all show at least $100M in direct damage, and some show damage costs far higher. Iconic structures like the Washington Monument and the National Cathedral were damaged. Even my organization, NIST, experienced minor damage in its main building.

The earthquakes I mentioned above all followed decades or even centuries of little activity on the faults where they struck and are sobering reminders of the unexpected tragedies that can occur. As it continues to gain new knowledge, the USGS updates 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 support from the California Earthquake Authority (CEA), jointly forecast a greater than 99% certainty of California's experiencing a M6.7 or greater earthquake within the next 30 years. The 2011 New Zealand earthquake, at M6.3, was slightly less severe than that which is postulated for California. And, the 2010 Chile and Japan earthquakes occurred in tectonic plate collision zones that are very comparable to those which generated the 1964 Alaska earthquake and more ancient earthquakes off the coasts of Oregon and Washington. Seismologists believe that the Chile and Japan earthquakes serve as clear warnings to us for what may occur again someday off the coasts of Alaska, Oregon, and Washington.

While concern for future earthquake activity is always great along our West Coast, the National Research Council has noted in its publications that 39 states in the U.S. have some degree of earthquake risk, with 18 of those having "high" or "very high" seismicity. For example, we know that the New Madrid sequence of earthquakes in 1811 and 1812 included at least four earthquakes with magnitudes estimated at 7.0 or greater centered in the "boot heel" of Missouri, and the 1886 Charleston, SC, earthquake caused widespread damage.

NEHRP was created to address the reality 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 needed research and translate the research results into actions that ensure that U.S. citizens are less threatened by devastating earthquakes. The NEHRP agencies work in partnership to perform a national service that cannot be duplicated by others, with each agency fulfilling its unique role without overlapping the roles and responsibilities of its partners. It is helpful to think of the NEHRP agencies and their partners as different organs in one body, vital and complementary. The studies and monitoring of the earthquake hazard cuts across both governmental and commercial boundaries. The research and implementation in both science and engineering by the NEHRP agencies is made possible by the "critical mass" they provide, which would not otherwise be possible if all responsibilities were left to the many states and (for the most part) small corporate entities that work in this field.

However, the NEHRP "family" extends beyond the four partner Federal agencies to include other Federal agencies, state and local governments, non-governmental professional organizations, model building code and standards organizations, and earthquake professionals in the private sector and academia. Without this extended "family" of dedicated earthquake professionals, the NEHRP agencies could not fully fulfill our statutory responsibilities. The earthquake professional "community" is relatively small and tightknit, but it is one of the most dedicated, technically competent, and integrated professional groups in the U.S.

NEHRP Organization, Leadership, and Reporting

NEHRP was established by the Earthquake Hazards Reduction Act of 1977 (Pub. Law 95-124; 42 U.S.C. § 7701 *et. seq*.), as amended by Public Laws 101-614, 105-47, 106-503, and 108-360. One of the great strengths of NEHRP over time has been the partnership that the legislation has fostered between the Legislative and Executive branches. The four NEHRP agencies look forward to continued close partnership with Congress through enactment of new authorizing legislation.

The National Earthquake Hazards Reduction Program Reauthorization Act of 2004 (Pub. Law 108-360), made significant changes to the earthquake hazards reduction program, establishing the NEHRP Interagency Coordinating Committee (ICC) and the external Advisory Committee on Earthquake Hazard Reduction (ACEHR), which continue to provide leadership to the program.

Interagency Coordinating Committee

The ICC has provided NEHRP leadership since 2006. This has resulted in a significant increase in program visibility in each agency and in the Executive Office of the President and has elevated key interagency decisions directly to the agency leader level. The direct involvement of, and interactions among, the agency leaders has improved program coordination and efficiency.

The ICC oversaw the development of the new NEHRP Strategic Plan that was released in October 2008, remaining engaged with its entire development. The ICC also oversees the development of NEHRP's annual reports, which summarize major activities of the Program.

Advisory Committee on Earthquake Hazards Reduction

By statute, the ACEHR assesses "trends and developments in the science and engineering of earthquake hazards reduction," as well as the effectiveness of the NEHRP Program in carrying out Program activities. The ACEHR also assesses Program management, coordination, implementation and activities, and the need for Program revision. The ACEHR first met in 2007, and consists today of 16 leading earthquake professionals from across the U.S., from all

walks of the non-Federal earthquake practitioner sector. The NEHRP agencies consider the ACEHR's expert advice as they formulate and implement their programs. In fact, the ACEHR is key in providing strategic vision to ensure that the NEHRP agencies align their efforts to address the most pressing issues concerning earthquake hazard assessment and risk mitigation.

Lead Agency

Public Law 108-360 designated NIST as the NEHRP Lead Agency with primary responsibility for planning and coordinating the Program. Lead Agency responsibilities are performed by the NEHRP "Secretariat" at NIST and include supporting the NEHRP Interagency Coordinating Committee (ICC) and the Advisory Committee on Earthquake Hazards Reduction (ACEHR); drafting and updating NEHRP strategic plans; submitting annual reports to Congress on NEHRP activities; and fostering interagency coordination and cooperation at the working level. NIST performs this work via a small in-house staff that is supplemented as needed by a contractor who provides administrative support; NIST also receives assistance from the other NEHRP agencies, especially from USGS, with routine Secretariat work. While NIST "leads" NEHRP activities, it is only with the teamwork of all the agencies working together under well-defined roles and responsibilities that NEHRP accomplishments occur. There is a genuine sense of common purpose, professionalism, and dedication to improving earthquake safety and resilience among the agency representatives, all of whom have worked together since my arrival at NIST in 2006.

NEHRP Strategic Plan

Public Law 108-360 required that the NEHRP agencies develop a new Strategic Plan. The agencies developed the Plan, starting with internal reflection supplemented by inputs from the earthquake professional community. Following over a year of comprehensive work, the agencies released a new Strategic Plan in 2008. The Strategic Plan presented a new NEHRP vision for our Nation:

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

This vision recognizes the importance of not only improving public safety in future earthquakes but also enhancing national economic strength and security. The vision highlighted the need for improving our national *resilience* in future damaging earthquakes. The NEHRP vision was one of the first recognitions of the vital national need for achieving *resilience,* which requires coordinated application of mitigation, redundancy, robustness, and response and recovery activities.

The Strategic Plan set three overarching program goals that involve synergies among the agencies:

- Improve understanding of earthquake processes and impacts (basic research);

- Develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society-at-large (applied research and development); and,

- Improve the earthquake resilience of communities nationwide (knowledge transfer and implementation).

The Plan also outlines nine areas of *strategic priority* for the program, areas of great importance to the Nation that will be emphasized more prominently *as resources become available to address them*: fully implement the Advanced National Seismic System (ANSS); improve techniques for evaluating and rehabilitating existing buildings; further develop performance-based seismic design (PBSD); increase consideration of socioeconomic issues 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 recovery planning; and, facilitate improved earthquake mitigation at state and local levels. The strategic priorities are essential to NEHRP's vision of moving the Nation towards greater earthquake resilience.

NEHRP Operational Structure

While it would be very difficult to characterize all of the NEHRP agency interactions graphically, Figure 1 (following page) provides a "snapshot" of many of the scientific and engineering interactions among the agencies needed to accomplish the NEHRP mission. Because each NEHRP agency is providing an overview of its specific activities during this hearing, I will only provide a brief summary here regarding agency roles and responsibilities.

USGS

The USGS is the applied earth science component of NEHRP. USGS delivers rapid characterization of earthquake size, location, and impacts; develops seismic hazard assessment maps and related mapping products; builds public awareness of earthquake hazards; supports targeted research to improve monitoring and assessment capabilities, and leads the NEHRP agencies' post-earthquake investigations. This brief statement is misleadingly short, because it covers so much activity and major contribution. USGS is also moving ahead with major new activities in assessing issues related to possible seismicity induced by the injection of large volumes of waste fluids into the ground during oil and gas recovery operations, and to working with other parties to initiate earthquake early warning activities for the U.S.

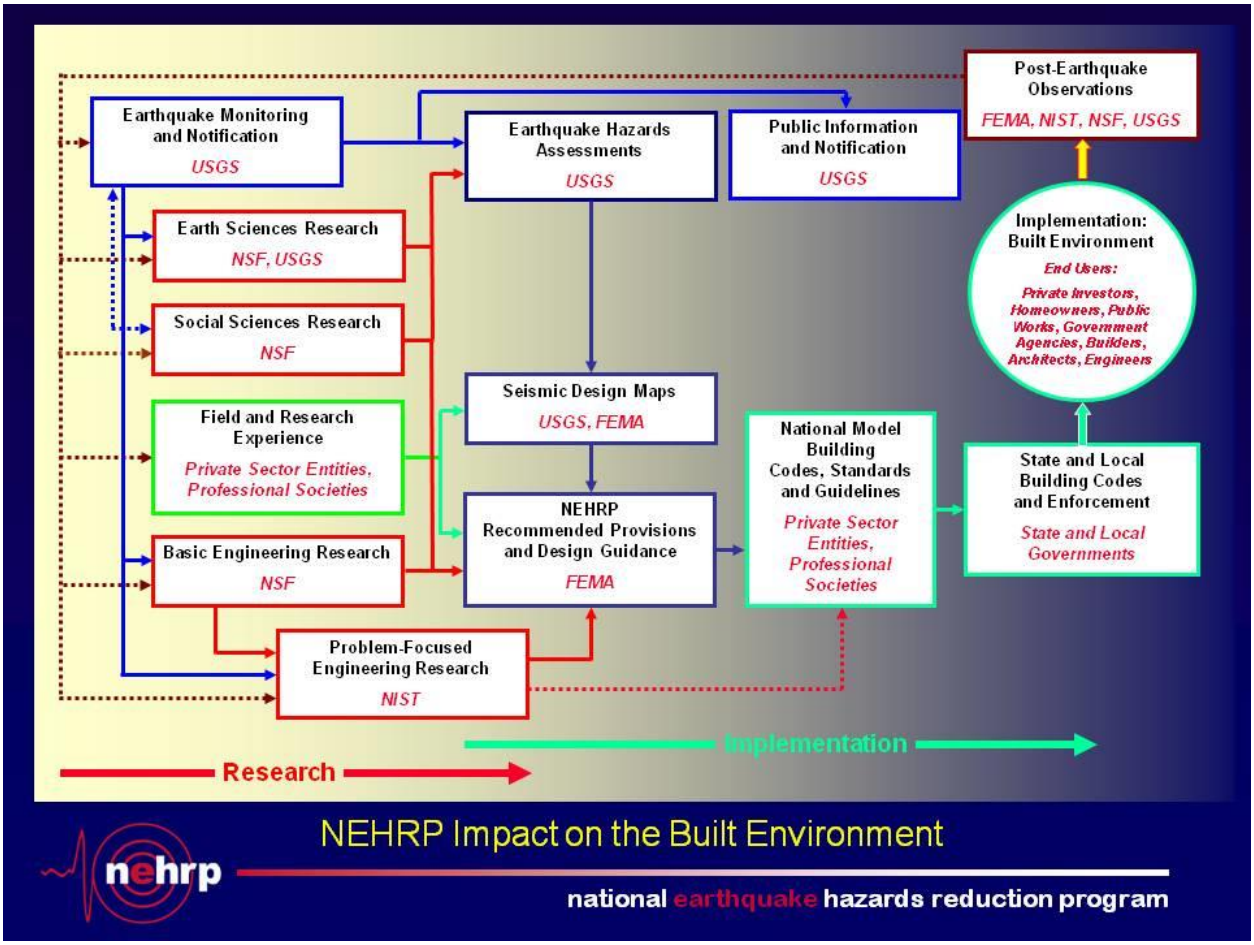

Figure 1. Primary NEHRP Activity Areas

NSF

NSF is NEHRP's primary basic research arm, supporting research that addresses earth science, geotechnical and structural engineering, lifeline engineering, and the social sciences, and integrating those disciplines. As a part of its support for basic research, NSF has provided resources to support operation of the 14 world-class experimental research facilities and cyber infrastructure in the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), which is now nearing the end of its initial ten year operational life. In addition to providing the basic research component of NEHRP, NSF supports the education of future generations of earthquake professionals across the Nation.

NIST

NIST's technical role in NEHRP is chiefly one of linking the basic research products that come from NSF-supported university research with the implementation activities that are largely led by FEMA. NIST's "linking" role primarily involves performing applied research. Such research translates and transfers the engineering products of basic research activities at major national

universities into tools that can be used directly or indirectly in building codes and standards, and in engineering practice. The NIST role is covered in more detail later in this testimony.

FEMA

FEMA is NEHRP's primary implementation and outreach arm. FEMA has the NEHRP leadership role in working with the practitioner community, the American Society of Civil Engineers (ASCE), and the International Code Council (ICC) to support the development of model building code and standards provisions that form the basis for most state and local building codes in the U.S. This work that results in development, publication, dissemination, and promotion of building design and construction materials is where much of NEHRP's "rubber meets the road."

To support and increase the adoption of NEHRP earthquake resilience measures, FEMA leads NEHRP efforts to 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.

In addition to portraying graphically many of the activities on the NEHRP agencies, Figure 1 emphasizes that NEHRP is incomplete without the significant contributions made by those outside the four agencies. The non-Federal earthquake community has been and remains a major factor in the historic success of NEHRP.

In addition to benefitting from the efforts of non-Federal players in the U.S., the NEHRP agencies work within their designated mission areas to foster appropriate ties to the international earthquake professional community. Not only can NEHRP-developed technologies be applied to help others, but the U.S. can learn from advances that are being made abroad. Members of NEHRP agency staffs, allied with the greater U.S. earthquake community, remain engaged with the international community in sharing information, methodologies, and technologies.

NEHRP Interactions with the Multi-hazard Community

In 2008, the Earthquake Engineering Research Institute (EERI) released a unique and informative report, *Contributions of Earthquake Engineering to Protecting Communities and Critical Infrastructure from Multihazards*. This report was commissioned by FEMA, and it addresses NEHRP-related activities. The report makes clear that its purpose was essentially two-fold. At one level, the report was formulated to inform the earthquake community, as well as the general public, of the leadership that has already been provided by NEHRP and those associated with it in improving "civil infrastructure and community resilience," and thus the "importance on long-lasting benefits of programs made possible through NEHRP." However, at a second, forward-looking, level, the report was written to "help define and encourage leadership." The report notes that leadership in earthquake engineering, largely involving NEHRP, sets a high

standard of performance. The report also notes that "future performance will be viewed increasingly in a multi-hazard context."

The NEHRP agencies have long fostered synergies among many diverse but necessarily interrelated disciplines to improve earthquake safety. Moving forward, the NEHRP agencies will seek new synergies with those who work to mitigate risks associated with other hazards (*e.g.*, wind, flood, and fire). This will be complex – while the ultimate goals of improved safety and resilience are common across hazards, there are similarities, differences, and linkages among the hazards that are being worked out in the multi-hazard community. Most of the technical issues that are 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. However, there are opportunities for the coordination of NEHRP activities with those that have parallels for other hazards. The 2008 EERI report provides a good start on considering some of those opportunities, and the NEHRP agency leaders hope to strengthen multi-hazard synergies across both technical and organizational lines in the future.

NIST Activities within NEHRP

NIST "wears two hats" within NEHRP.

First, NIST performs statutory Lead Agency duties for the NEHRP. These Program-wide activities were described in more detail previously in this testimony.

Second, NIST performs applied research to develop and deploy advances in measurement science related to earthquake engineering - including performance-based tools, guidelines, and standards for designing buildings to resist earthquake effects and improve building safety; and to enhance disaster resilience of buildings, infrastructure, and communities. NIST NEHRP applied research develops the scientific basis required to enable technological innovation, improve predictive capabilities, and improve building codes, standards, and practices for the cost-effective improvement of disaster resilience, including life-safety and reduction of property loss and economic disruption.

After a number of years of reduced earthquake engineering research activity, NIST began rebuilding its earthquake research program in 2006. A 2003 Applied Technology Council (ATC) report, *The Missing Piece: Improving Seismic Design and Construction Practices* (ATC 57), identified a major technology transfer "gap" between the basic earthquake-related research supported by the National Science Foundation (NSF) and the efforts of the Federal Emergency Management Agency (FEMA) to assist in developing earthquake-related provisions of national model building codes and standards. The ATC report highlighted this gap as a serious national deficiency that hampers transferring new technologies into design and construction, which is manifested by a lack of measurement science in several key areas of engineering for both new

and existing buildings, as well as for lifelines (*e.g*., transportation networks, water and sewer supply and distribution, energy supply and distribution, communications and data transfer).

The last point is becoming particularly important. As national leaders realize the need for improved resilience with respect to all hazards, the criticality of lifeline resilience in sustaining quality of life and economic strength will become more prominent. The Nation's infrastructure is aging and, in many areas, deteriorating. Maintaining the serviceability of lifeline systems is critical to societal resilience, and the interconnectedness of separate (not independent) lifeline systems is a major factor in their serviceability and in societal resilience.

NIST set out to "bridge" the technology transfer gap with an applied earthquake engineering research program that was formulated with the NEHRP partner agencies and with leading researchers and practitioners in a multi-step process. First, the NEHRP agencies jointly developed the *Strategic Plan for the National Earthquake Hazards Reduction Program, Fiscal Years 2009-2013,* which was briefly describe earlier in this paper. In 2011, the National Research Council (NRC) completed a NIST-commissioned study that produced a twenty-year "roadmap" for improved U.S. earthquake resilience, *National Earthquake Resilience: Research, Implementation, and Outreach*. The roadmap endorsed the broad goals and objectives of the NEHRP Strategic Plan and provided a comprehensive perspective on accomplishing the Strategic Plan goals and objectives that was developed by leading North American earthquake professionals outside the Federal agencies. Following the release of the NRC report, NIST commissioned the Building Seismic Safety Council (BSSC) to develop a ten-year research roadmap for recommended NIST-specific research that encompasses the ATC 57 philosophical goals, the NEHRP Strategic Plan, and the broad research directions set by the NRC study. BSSC released this roadmap report, *Development of NIST Measurement Science R&D Roadmap: Earthquake Risk Reduction in Buildings* (NIST GCR 13-917-23) in early 2013.

Electronic files (Adobe pdf format) of all the reports mentioned above are available on the NEHRP web site (www.nehrp.gov).

From 2006 through 2013, individual NIST NEHRP research projects followed the "ATC 57 roadmap philosophy" and satisfied needs that were identified by leading earthquake engineering practitioners and researchers in various national publications and validated through interactions with engineers who are actively developing national standards for seismic design, primarily the American Society of Civil Engineers (ASCE) Standard, *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI 7-10), which forms the basis for the structural design provisions for the most widely recognized U.S. model building code, *The International Building Code*. The 2013-2014 NIST NEHRP program began a transition to the BSSC roadmap work and this transition continues for FY 2014. Key features of the ongoing and proposed work are significant interactions with the partner NEHRP agencies, integrated analytical and experimental research, and continuing engagement with leading earthquake researchers and practitioners in the private sector and in academia. In addition, NIST memberships in the BSSC Provisions Update Committee (which is supported by FEMA and USGS); the American Society of Civil

Engineers/Structural Engineering Institute (ASCE/SEI 7) Seismic Subcommittee; ASCE Standards Committee on Evaluation and Retrofit of Existing Buildings (ASCE/SEI 41); and corresponding American Concrete Institute (ACI) and American Institute of Steel Construction (AISC) technical committees brings the latest technical ideas to the NIST program. These same memberships also facilitate more effective transfer of new knowledge gained through NIST research into the practitioner community.

The ATC 57 report also recommended that NIST continuously engage the earthquake engineering research and practitioner communities in its activities, to ensure effective knowledge transfer into and out of NIST. To implement this, NIST R&D is performed through a partnership of core in-house and world-class extramural expertise. The contractor partnership affords NIST access to leading, world-class U.S. and, on occasion, international earthquake researchers and practitioners within the required technical disciplines. Since 2007, NIST has accomplished its research through two task order contracts, first with the NEHRP Consultants Joint Venture (NCJV), and then with the Applied Technology Council (ATC). In the life of the two contracts to date, 243 individual consultants (leading practitioners and researchers, outstanding graduate students) have filled 473 research positions in 38 research task order projects for NIST. The work in those projects has directly contributed to 27 PhD dissertations or MS theses around the U.S. In addition, the NIST engagement has provided technical information for application by graduate students in their research and by practitioners around the U.S. and the world.

Paralleling the BSSC-recommended approach, the NIST NEHRP program is subdivided into five complementary research program elements:

- Program Element 1: *Improved Building Codes and Standards Provisions.* Program Element (PE) 1 consists of short-term practical, applied research projects that improve seismic design practice and building standard and code development. National model building codes contain prescriptive seismic provisions, many of which have evolved from practitioner experience, without specific research results to substantiate them, and PE 1 is devised to provide those research results.

- Program Element 2: *Performance-Based Seismic Engineering (PBSE) for New and Existing Buildings.* PE 2 emphasizes developing the technical basis for performance-based seismic engineering (PBSE) and focuses on developing metrics for measuring performance and acceptance criteria for different performance objectives. A major factor in PBSE is the requirement for performing accurate nonlinear analysis of building performance during different earthquake shaking intensities, which enables more cost-effective and creative design approaches than those possible by applying the prescriptive rules that are predominant in current building codes.

- Program Element 3: *Lateral Force-Resisting Structural Elements and Systems.* PE 3 focuses on developing higher fidelity models for predicting the seismic performance of Lateral Force-Resisting Structural Elements and Systems through experimental and/or

experiential validation. PE 3's primary goal is to improve seismic engineering practice via performing and analyzing laboratory testing.

- Program Element 4: *Tools and Guidelines for Improved Earthquake Engineering Practice.* PE 4 develops synthesis documents, most of which are known as "techbriefs," that distill research findings, findings of professional committees and task groups, and cost-effective and code-compliant detailing practices into forms usable by practitioners. Techbriefs have been produced extramurally at the rate of one or two per year. The techbriefs that have been produced to date have been received most positively by practitioners and educators. Practicing engineers keep the reports on their desk as direct references in their design work. Educators use the techbriefs as information sources in their classes – this is particularly true for graduate classes.

- Program Element 5: *National Earthquake Hazards Reduction Program (NEHRP) Coordination.* PE 5 supports all activities of the NEHRP "Secretariat", which was described previously in this paper. The Office also supports NIST's role as lead agency for the U.S.-Japan Cooperative Program in Natural Resources (UJNR) Panel on Wind and Seismic Effects and the federal Interagency Committee on Seismic Safety in Construction (ICSSC).

Program Elements 1-4 address major topical areas of earthquake engineering research for improved design and construction of new and existing buildings, with primary emphasis now placed on research related to new buildings. Research in the existing buildings area will ultimately be needed to support earthquake resilience in communities, since a large percentage of the existing building stock will remain in use. Similarly, research in the lifelines area will be needed in the future to support community earthquake resilience. NIST has funded a lifelines research and implementation road-mapping effort with the Applied Technology Council that should be completed by the end of FY 2014. That effort is showing the criticality of lifelines to ensuring community resilience across all hazards, natural and man-caused, not just earthquakes.

Given the unique and fundamental nature of the necessary interaction between FEMA and NIST 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 critical projects that involve complementary topic areas. A current example of the partnership in action is FEMA and NIST are cooperating on structural engineering research and implementation projects that support work underway in Los Angeles involving older nonductile ("brittle") concrete buildings; the Los Angeles work also involves earlier work funded by NSF and ongoing work by USGS in directly supporting the City of Los Angeles.

Practical Observations on Possible NEHRP Reauthorization Legislation

Finally, i will offer some personal thoughts on possible reauthorization legislation for NEHRP. I provide the following brief general reflections on implementing Public Law 108-360, which has guided the NEHRP agencies since my arrival at NIST in early 2006. I intend my remarks to be constructive in continuing the NEHRP partnership.

In recent years, both the House of Representatives and the Senate have considered new reauthorization language. Rather than assessing any of those bills that we have seen, I shall focus on Public Law 108-360.

First, the agencies will welcome the reinvigorated partnership with the Legislative Branch of our government that reauthorization would reflect. This program, which has existed for over 35 years, is vital to all aspects of improving earthquake safety in our Nation. Earthquakes cross state boundaries, so that state-Federal partnership is vital. Solutions to earthquake-related problems can best be handled in a coordinated manner that crosses those boundaries. In addition, the engineering community that addresses almost all earthquake problems is composed of many small entities, not corporate giants, so that private sector mass is simply inadequate to address major challenges in hazard assessment and research. Federal leadership is critical to this endeavor.

Second, as a practical matter for clarity of Congressional authorization for major natural hazard assessment and risk mitigation activities in the government, I believe it is most sensible to combine the legislation for the different hazards into a single bill. Particularly when the growing interests in broader resilience and multi-hazard activities are considered, a single authorization would enable the most efficient implementation of Congress's intent.

Next, allow me to address a number of NEHRP operational issues:

The creation of the Interagency Coordinating Committee (ICC) is a strength of Public Law 108-360, facilitating the exchange of information and fostering senior level coordination among the agencies. However, the experience we have gained since 2006 indicates that the requirement for agency leaders to meet thrice yearly is impractical, given the leaders' busy schedules and work demands. An alternative goal is keeping the ICC as a body alive and planning one scheduled meeting per year for those leaders, with other meetings called on an as-needed basis, possibly for leaders' designated representatives. And, since there has been a discussion of creating a "combined" ICC that joins the senior leaders of both the NEHRP and the National Windstorm Impact Reduction Program (NWIRP) agencies, the manner in which the ICC is organized bears re-consideration.

The creation of the Advisory Committee on Earthquake Hazards Reduction (ACEHR) is another genuine strength of Public Law 108-360. The ACEHR should be continued, with its providing biennial reports to the ICC Chairperson (NIST Director) on the "state of NEHRP" also continued. NEHRP has also set a policy of including the Chairperson of the USGS Scientific

Earthquake Studies Advisory Committee (SESAC) as an *ex-officio* member of the ACEHR. Paralleling the ongoing consideration of a "combined" ICC, some effort to examine the "pros" and "cons" of having an advisory committee that jointly addresses both NEHRP and NWIRP, as opposed to separate advisory committees for the two programs, might be considered. Issues to be weighed include efficiency of managing advisory committee logistics, provision of multi-hazard perspectives, and level of focused technical depth for each hazard area.

The ICC and indeed NEHRP are required by Public Law108-360 to produce two documents, a Strategic Plan and an Annual Report. NEHRP produced its Strategic Plan in late 2008 and initially labelled it as a plan covering FY 2009-FY 2013. As has been mentioned above, the earthquake community in general and the National Research Council (NRC) in particular have strongly endorsed the Plan for its strategic direction. The NRC laid out a 20-year "roadmap" for earthquake research and implementation work, essentially endorsing the Plan as a long-range document. With this in mind, it would be wise to consider the need for periodic reviews of the Plan, with accompanying updates, as opposed to creating a completely new Plan in the near term.

Prior to the enactment of Public Law 108-360, the NEHRP agencies had been required by statute to produce a biennial report on NEHRP activities, but Public Law 108-360 increased the requirement to annual reporting. Given the substantial effort required to produce an informative report covering four agencies' activities, a return to biennial reporting is a cost-effective measure to consider. Recognizing the interest in both Congress and the public-at-large in knowing the NEHRP agencies' budgets, it would be realistic to continue reporting budget data annually.

As a part of the basic annual report requirement, Public Law 108-360 requires that the report be submitted at the time each year when the President submits the annual budget request. It would be beneficial to weigh the merits of the current annual reporting requirement against a less frequent reporting requirement. For example, prior to Public Law 108-360, NEHRP reports were statutorily required on a biennial basis. This consideration is one of balancing effort required to develop these reports with frequency of Congressional need for Program updates. Regardless of the required frequency of reports, a "due date" that is a reasonable time period after the President's budget request submission would be helpful to the agencies in collecting data and developing a well-structured report.

Closely tied to the annual reporting requirement is the requirement in Public Law 108-360 for the NEHRP agencies to "coordinate" their budgets. It would be helpful for Congress to clarify its direction to the agencies on this point. Given the many complexities of the appropriations process, it seems likely that the original intent of the current requirement was really intended to focus on *Program* coordination, rather than budget coordination, both to avoid duplications of effort and to maximize leveraging of agency efforts

Public Law 108-360 contains language that designates USGS as the NEHRP Lead Agency for post-earthquake investigations. NIST believes that USGS is best qualified among the NEHRP agencies to fulfill that role. Its expertise, experience, strategically placed geographic locations for

its offices, and well-established relationships with critical state offices are key to rapid engagement following future U.S. earthquakes. In addition, its international focus gives USGS established relationships with its peers around the world, thus enabling rapid contact and deployment, almost regardless of location. In the end, all of the NEHRP agencies will work together on future post-earthquake investigations, but we strongly believe leadership for future investigations is best provided by USGS.

An important feature of Public Law 108-360 was the statement of congressional support for major NEHRP-related research and monitoring systems, such as the Advanced National Seismic System (ANSS), Global Seismographic Network (GSN), and the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). Past reports of the NEHRP ACEHR (see http://www.nehrp.gov/committees/reports.htm) have provided assessments of these systems, as well as of other features of NEHRP.

There have been numerous technical and policy developments in the years since Public Law 108-360 was enacted. These include a growing national focus on resilience in natural disasters – restoring normality with a minimum of social and economic disruption. In considering NEHRP re-authorization, Congress may wish to review and comment on relevant resilience-related topics such as evaluation and strengthening of existing buildings, functionality of lifelines, earthquake early warning, and the interaction of the social sciences with research and implementation work in the more traditional engineering fields.

Conclusion

Recent earthquakes serve to remind us of their episodic nature – especially their inevitability and unpredictability. There is nothing we can do to stop them. But the impacts of earthquakes, while not completely avoidable, can be greatly reduced. The NEHRP agencies and their partners, given comprehensive direction by Congress, have accomplished much in hazard assessment and risk mitigation since the 1970's. The NEHRP agencies stand ready to continue their work to improve the resilience of our country.

Chairman Bucshon, Ranking Member Lipinski and other Subcommittee members, thank you again for the opportunity to testify on NEHRP activities. This concludes my remarks. I shall be happy to answer any questions you may have.

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Dr. Hayes joined NIST after serving as leader of seismic and structural engineering research at the U.S. Army Engineer Research and Development Center's (ERDC) Construction Engineering Research Laboratory (CERL) in Champaign, IL, from 1988 until early 2006. At CERL, Dr. 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 was directly involved with a number of significant earthquake mitigation projects for FEMA. Working with key personnel at USGS, Dr. 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, Dr. 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). Dr. Hayes is a retired U.S. Air Force Lieutenant Colonel and is a registered Professional Engineer in Virginia.

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