STATEMENT

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

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before the

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Subcommittee on Science, Technology, and Space

The National Earthquake Hazards Reduction Program
and
Fire Research Program
Reauthorization Hearing

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Mr. Chairman and distinguished members of the Subcommittee, I appreciate the opportunity to testify for the National Institute of Standards and Technology (NIST) on the reauthorization of the National Earthquake Hazards Reduction Program (NEHRP) and the Fire Research Program. Incidentally, this is the first Senate hearing we have had on the fire research program in nearly a decade. These are very important programs for NIST. Both of these programs are rooted in law, deal with interrelated technologies and along with our wind research, address increasingly costly hazards. Both programs are carried out in partnership with FEMA, other Federal agencies, and numerous public and private sector bodies. Both of these programs reside within our Building and Fire Research Laboratory which has enabled us to build synergy in our research related to earthquake, fire and wind hazards. We all seek to find ways to make government work better and to collaborate more effectively within and across agencies to address important national needs. In my view, these programs are exemplary in that regard, yet I know Director Witt shares my commitment to continue to make them even more productive.

National Earthquake Hazards Reduction Program, NEHRP

NEHRP is the Federal Government's program to reduce the risks to life and property from earthquakes. NEHRP consists primarily of four federal agencies: the Federal Emergency Management Agency (FEMA), the United States Geological Survey (USGS), the National Science Foundation (NSF), and the National Institute of Standards and Technology (NIST). These four agencies work in cooperation with each other and with other organizations to carry out NEHRP's mission, "to develop and promote knowledge, practices, and polices that reduce fatalities, injuries, and economic and other losses from earthquakes."

NIST's legislatively-mandated role in NEHRP is to conduct problem-focused research and development to improve codes, standards, and practices for buildings and infrastructure lifelines, and to

- promote better building practices among architects and engineers;
- work with national standards and model building code organizations to encourage implementation of research results; and
- work with national standards organizations to develop seismic standards for new and existing lifelines.

NIST also chairs and provides the technical secretariat for the Interagency Committee on Seismic Safety in Construction (ICSSC) which recommends practices and policies to reduce earthquake hazards in federally owned, leased, assisted, and regulated facilities.

NIST's role in NEHRP complements the lead agency role of FEMA, the applied earth sciences role of USGS, and the fundamental engineering and earth sciences role of NSF. This role is consistent with the mission of the NIST Laboratories "to provide technical leadership for the Nation's measurement and standards infrastructure, and assure the availability of essential reference data and measurement capabilities."

NIST provides substantial technical and research support to FEMA in the development of recommended standards and practices for design and construction of new buildings; for evaluation, strengthening and repair of existing buildings; and for lifelines. The private sector participates strongly in all areas and provides the formal standardization to which NEHRP contributes recommendations.

NIST's activities in support of the NEHRP Strategic Plan include: (1) leadership and participation in ICSSC; (2) problem-focused research and development to improve codes, standards, and practices; and (3) leadership and participation in standards and international activities.

NIST is a member of the Interagency Coordinating Council (ICC) which provides policy-level direction in the preparation of the coordinated and consolidated budget for NEHRP and its presentation to the Office of Management and Budget, and the development of the Strategic Plan for NEHRP. ICC also coordinates the execution of the NEHRP program including: preparation of Congressionally-mandated studies, collaborations with private and public sector elements of the earthquake community, and development of the biennial NEHRP report to Congress.

NIST devoted $2,000,000 and $2,060,000 of its Building and Fire Research appropriation for NEHRP in Fiscal Years 1998 and 1999, respectively. These amounts, represent about 2% of the NEHRP budget.

Now, I would like to briefly report highlights of several of our recent accomplishments.

Development and Implementation of Earthquake Loss Reduction Practices through ICSSC -- The Interagency Committee on Seismic Safety in Construction (ICSSC), composed of representatives of 32 Federal agencies, was established in 1978 as part of NEHRP. ICSSC makes recommendations to its constituent agencies on practices and policies to reduce earthquake hazards in their programs, including federally owned, leased, assisted, and regulated facilities. Recommendations are developed through consensus of the Committee. NIST provides the chair and the technical secretariat, with funds from FEMA. The chair of the ICSSC is the Director of NIST or his designee (Public Law 101-614). The main accomplishments of ICSSC during this reporting period are summarized below.

ICSSC recommended and wrote Executive Order 12699, *Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction* (signed January 5, 1990), which directs Federal agencies to issue regulations or procedures that incorporate cost-effective seismic safety measures for all **new** Federal buildings and buildings that are leased, assisted, or regulated by the Federal Government. ICSSC is responsible to FEMA for the recommendation for adoption of cost-effective seismic design and construction standards and practices required by the Executive Order.

ICSSC issued a Recommendation to Federal agencies in January 1999 based on a study comparing the 1994 *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings* to the most recent editions of the three national model building codes, the American Society of Civil Engineers (ASCE) 7-95 *Minimum Design Loads for Buildings and Other Structures*, and the Council of American Building Officials (CABO*) One and Two Family Dwelling Code* (ICSSC TR-20/NIST GCR 98-755, August 1998). ICSSC found that, with certain exceptions, only the 1997 Uniform Building Code of the International Congress of Building Code Officials (ICBO) and ASCE 7-95 provide a level of seismic safety substantially equivalent to the 1994 *NEHRP Recommended Provisions.* These recommendations will affect compliance with Executive Order 12699 beginning in FY 1999 for those agencies which use one of the codes judged to be non-equivalent to the 1994 *NEHRP Recommended Provisions.* Affected agencies may choose to adopt either the 1994 or, the more recent, 1997 *NEHRP Recommended Provisions* to implement the requirements of the Executive Order.

ICSSC recommended and wrote Executive Order 12941, *Seismic Safety of Existing Federally Owned or Leased Buildings* (signed December 1, 1994), which requires each Federal agency that owns or leases buildings to apply minimum seismic safety standards to such buildings, prepare an inventory, and provide seismic risk mitigation cost estimates. The Executive Order also requests FEMA, in consultation with ICSSC, to prepare for Congress, by December 1, 2000, a report on how to establish an economically feasible, comprehensive, and long-range program for the seismic rehabilitation of Federal buildings. NIST is responsible for providing technical assistance to the Federal agencies in the implementation of the Executive Order.

ICSSC conducted three "How-to-Comply" workshops to assist Federal agencies in complying with Executive Order 12941. The workshops also led to recommend changes to the ICSSC Recommended Practice RP-4, *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings.*

Problem-Focused R&D to Improve Codes, Standards, and Practices -- NIST is addressing key enabling technologies for performance-based seismic standards. They include: structural control for improved seismic protection, evaluation of structural analysis methods used in current seismic design provisions, new design approaches to integrate the use of structural control devices, seismic rehabilitation of welded steel-frame buildings, enhanced control of post-earthquake and wind-driven fires, structural performance of housing systems, and the use of fiber-reinforced polymer composite materials in strengthening and repair applications.

In partnership with the American Institute of Steel Construction (AISC) and three universities (the University of California at San Diego, the University of Texas at Austin, and Lehigh University), NIST led the development of comprehensive guidance for seismically upgrading welded steel-frame buildings. The guidelines were developed in response to the large number of beam-to-column connections that failed during the 1994 Northridge, California earthquake. They provide experimentally-validated response

prediction models and design equations for three promising concepts that shift loading from the brittle weld joints into the beams, thus enabling the structure to absorb the earthquake's energy in a non-brittle manner. NIST determined the concepts, designed the test specimens and experimental program, developed performance criteria and evaluation methods, provided technical oversight for the testing conducted at partnering universities, and coordinated its effort with FEMA and the Structural Engineers Association of California (SAC) Joint Venture. AISC, which issues the design standard for structural steel buildings, has published the guidelines in its Steel Design Guide Series. Use of the guidelines will increase the safety of thousands of similar buildings located in the U.S. and throughout the world. Upgrading 50 percent of about 10,000 existing buildings at $10 to $30 or more per square foot in "high" seismic regions of the U.S. alone is estimated to cost between $2 billion and $5 billion.

Guidelines for pre-qualification, prototype, and quality control testing of seismic isolators, developed by NIST, in cooperation with manufactures, researchers, and practitioners, are now in the final stage of adoption as a national standard by the ASCE. NIST is also nearing completion on similar test guidelines for passive energy dissipation devices. These protective devices are used in retrofits and new construction to isolate structures from seismic shaking (isolators) and to dissipate energy without structural damage (passive energy dissipation devices) during large earthquakes and extreme winds. Adoption of the NIST-developed test guidelines in national standards will enable widespread use of structural control systems to provide greater protection to structures and their occupants, reduce damage and economic losses from future earthquakes, and allow structures to perform better and more cost-effectively.

An innovative connection system for precast concrete buildings in seismic regions, developed by NIST in partnership with the private sector and the American Concrete Institute (ACI), has received product approval by the Evaluation Service of ICBO. The hybrid system uses two kinds of steel to connect the precast concrete structural elements -- high-strength tensioning steel to provide strength and stiffness by clamping the connection, and low-strength mild steel to dissipate the earthquake energy in a non-brittle (plastic) manner. NIST conducted 1/3-scale model experiments and analytical research to evaluate the performance of structures built using the hybrid connection system. The research showed that the innovative precast concrete connection system performed as well as, and in some cases better than, monolithic concrete connections, thus making it possible to use precast construction in high seismic regions. Based on the results of its research, NIST developed guidelines for the design of structures using the hybrid connection system.

ACI, which issues the national standard for design and construction of concrete structures, has developed a provisional standard for the hybrid connection system. The new connection has been used in four construction projects and will be used in a new $128-million, 39-story, 420-ft-high precast concrete building in San Francisco -- the tallest concrete frame ever built in the high-risk seismic Zone 4 -- that is slated to begin construction in August 1999. The connection is also under consideration for several mid-

rise hotels in Long Beach and the greater Los Angeles area. Fortune Magazine (September 8, 1997) estimates savings of $5 to $10 per square foot in construction costs through use of the new system in comparison with a steel or cast-in-place concrete structure. Other benefits include smaller anticipated repair costs after a seismic event and a significant reduction in project delivery time.

NIST is developing a methodology for simulating the ignition and spread of post-earthquake fires to improve control of fire, and to reduce the vulnerability of buildings and communities. Historically, post-earthquake fires have been a principal source of earthquake loss. This includes research to simulate highly localized, radiation dominated fires of critical importance to post-earthquake fire scenarios. These high-heat fires interact strongly with the local topography (natural and manmade) and the vertical distribution of wind and temperature in the atmosphere.

The 1997 NEHRP Reauthorization Act (P.L. 105-47) requested NIST to work with NSF, FEMA, and USGS "to develop a comprehensive plan for earthquake engineering research to effectively use existing test facilities and laboratories (in existence at the time of the development of the plan), upgrade facilities and equipment as needed, and integrate new, innovative testing approaches to the research infrastructure in a systematic manner."

NIST has been working with NSF on issues related to experimental earthquake engineering. As a result of NIST's efforts, Federal laboratories will be electronically networked into the National Network for Earthquake Engineering Simulation (NEES) using NSF funds. They are eligible to receive NSF funds to upgrade their existing facilities or build new facilities if the broader earthquake engineering community justifies the need for such an investment on a case-by-case basis. Several Federal government laboratories, such as the U.S. Army Waterways Experiment Station (WES) and Construction Engineering Research Laboratories (CERL), the Federal Highway Administration (FHWA), and NIST, have unique experimental capabilities for earthquake engineering research paid for through public funds. For example, collectively, these laboratories have a geotechnical centrifuge, a large shake table, a large reaction wall, and a multi-directional test facility and strong floors. The laboratories are professionally managed and maintained by each agency and are equipped to carry out full-scale testing programs, including data acquisition and analysis. Federal participation in NEES will provide participants access to Federal equipment and operators, assistance in fabricating and instrumentation of test specimens, and on-site office space for the duration of the testing phase.

Fire Research Program

Now, I will briefly review NIST's responsibilities under the Fire Prevention and Control Act (Public Law 93-498), our recent progress, and plans. By way of overview, we have made great strides, yet we still face a challenge, one that could offset much of what we have gained in the last 25 years.

The Fire Prevention and Control Act, enacted October 29, 1974, established, among other things, a fire research center within the Department of Commerce, National Institute of Standards and Technology (NIST). The mission of this center is to perform and support research on all aspects of fire with the aim of providing scientific and technical knowledge applicable to the prevention and control of fires. The Act further stipulates that the content and priorities of the research program shall be determined in consultation with the Administrator of the National Fire Prevention and Control Administration, now known as the United States Fire Administration (USFA). In short, NIST is the Nation's leading fire research laboratory and the focal point for fire research within the national government, and the USFA has overall responsibility for national fire safety policy and programs. These are clearly distinct yet highly interrelated responsibilities.

NIST and the USFA have a working relationship and a formal agreement for coordination of priorities and programs. Specifically, USFA provides a perspective on the needs of the fire service organizations for NIST in the formulation of our research priorities and programs. Similarly, NIST works closely with USFA in the dissemination and transfer of results of our research relevant to the needs of the fire services.

It will soon be 25 years since passage of this historic legislation. The Fire Act followed on the heels of the dramatic and stirring report of the Presidential Commission on Fire Prevention and Control, "America Burning," which graphically depicted the horrors of fire and its human and material toll. Following passage of the Fire Act, we set a goal for our research efforts of 50% reduction of fire deaths. Our strategy was a two-path effort. One involved identifying the most common scenarios leading to fire death and developing intervention strategies and technologies. The other involved more fundamental research aimed at developing sufficient understanding of fire to ultimately "engineer" fire safety into materials, products, systems and facilities.

We have made good progress on both efforts. Working in partnership with other federal agencies, many private sector bodies, and the fire services, the U.S. fire death rate has indeed been reduced by very nearly 50% according to National Safety Council statistics. NFPA data reveal the number of reported fires has been reduced by 40%. Most experts credit these reductions in fire losses to advances in smoke alarms, sprinklers, more fire resistant products, and more effective fire safety education and information. NIST has been a significant contributor to every one of these developments. Specifically, the most critical set of fire scenarios turned out to involve residences, and combinations of smoking materials or small ignition sources, upholstered furniture or bedding, nighttime, and some degree of human incapacitation. NIST contributions included test methods for smoke detectors, cigarette ignition resistance of mattresses and upholstered furniture, flame spread on carpets and rugs. NIST also developed what is now a national and international standard for heat release rate measurement, the cone calorimeter which has helped guide industry to lower flammability products and materials. NIST developed computer-based models of room fire growth and smoke movement throughout buildings are now used routinely by fire protection engineers, firefighters and educators. Models and real scale fire tests developed and fostered by NIST led to quantification of the rapid rate of onset of

"flashover" (or full room fire involvement) from a small household fire that is now widely used in public service announcements, and fire safety training. The results of NIST research have become the basis for new practices, standards, code provisions, new and ubiquitous technologies such as residential smoke detectors, and fire safety education materials used in schools and by the fire services around the world.

The results of NIST research on the more fundamental research path are even more significant. The research carried out by NIST, and its academic grantees supported over the years, has established firmly a body of knowledge now accepted as "fire science and engineering." Important manifestations of this development are:

- emergence of highly acclaimed textbooks and handbooks on fire science and engineering,
- establishment of fire safety engineering curricula in a growing number of colleges and universities, and the
- emergence of fire safety engineering as an accredited engineering profession.

These developments in turn are fueling a global movement to performance-based fire safety standards and codes. These investments in fire research made through the fire research center at NIST have contributed significantly to these improvements.

This expanding knowledge base is as relevant to mall, factory, automobile, aircraft, ship, urban wild-land, post-earthquake, and terrorist-instigated fires as it is to residential fires. Cycle time reduction and the pace of commerce are both rapidly increasing in every sector of the economy. So are the complexities and interdependencies of the systems, which make up our society, as we become increasingly dependent on advanced technologies. Buildings are getting bigger and more complex. So are aircraft and ships. The value density and fire damage vulnerability of the contents of factories, offices and even homes are increasing with increasing dependence on highly sophisticated equipment and systems. Thus, for fire risk to continue to decline, fire protection technologies must become more proactive and reliable in function.

Consider the following possibilities:

- comfortable home furnishings and bedding that pose no fire risk,
- factories and warehouses that are reliably fire safe,
- structural systems that will not collapse catastrophically in the event of a fire,
- fires that can be sensed before they become significant,
- fire fighters who can extinguish building fires without significant personal risk of loss of life to themselves.

Our job at NIST is to think about these sorts of things: to provide cost-effective measurement and prediction tools to help assure that the bad ones don't happen and the good ones can, and to provide the knowledge and tools needed by fire services, fire protection engineers, and industry.

Recently, my colleague, FEMA Director, James Lee Witt, commissioned a group of fire service leaders to conduct a Blue Ribbon Study of the United States Fire Administration. The Panel's recommendations are primarily focussed on the USFA and those research issues raised by the fire services. But they also speak to a number of unmet research needs, NIST's role as leader of the fire research community, and its efforts to team with the USFA in re-establishing a truly national effort to improve fire safety. The Panel's report also talks about the critical role of NIST and others in meeting national fire safety goals and the urgency of developing a "national fire research agenda" and roadmap. The Panel's recommendation also urges $10 million per year in additional funding for these R&D needs plus an additional $2 million for fire research grants to academic and other allied institutions. I strongly support these recommendations and see the NIST-FEMA partnership as important in carrying them out.

I believe enhanced research leading to "cost-effective assured fire safety" could lead to a reduction of the burden of fire by 20%. This would include, we estimate conservatively, a further reduction of at least 1000-1500 fire deaths per year from improved materials, and more reliable and cost-effective sensing and suppression technologies. Further, major reductions in the economic burden of fire would come from reduction of redundant, outdated, and/or functionally ineffective requirements present in many existing codes and standards. Additionally, major gains in fire fighting effectiveness are achievable as well as reductions in fire fighter risk. Similar gains would come from being able to produce products and buildings designed and built with markedly lower fire risk.

We have come a long way in reducing fire deaths and the number of fires in the United States. NIST-conducted and sponsored fire research has played a major role in this remarkable feat, however, our job is far from finished. We believe the Nation needs to move toward assuring the delivery of cost-effective "assured fire safety." We believe it is critical to the future well-being of the Nation's citizens, and the future effectiveness and safety of our fire fighters. We believe it is a requisite to global competitiveness of U.S. industry.

I appreciate the opportunity to appear before you today and would be pleased to address your questions.