Statement of Dr. Sharon L. Hays
Associate Director & Deputy Director for Science
Office of Science and Technology Policy
to the
Subcommittee on Technology and Innovation
Committee on Science and Technology
United States House of Representatives
"The National Windstorm Impact Reduction Program: Strengthening Windstorm Hazard Mitigation"
July 24, 2008

I. Introduction

Chairman Wu, Ranking Member Gingrey, and Members of the Subcommittee, I am pleased to appear before you today to describe interagency activities related to the National Windstorm Impact Reduction Program (NWIRP). Wind hazards (hurricanes, tornadoes, severe windstorms) are among the most destructive and economically damaging hazards in the U.S. While other hazards strike irregularly, wind storms produce enormous damage in the U.S. year after year.

Reducing the likelihood and impact of natural and technological[1] disasters requires an understanding of science and technology, the transformation of research into disaster reduction programs and applications, and access to information from both public and private entities. In order to meet these challenges, the inter-agency Subcommittee on Disaster Reduction (SDR) of the National Science and Technology Council (NSTC) was chartered in 1988. The SDR provides a unique federal forum for information sharing, development of collaborative opportunities, formulation of science- and technology-based guidance for policy makers, and dialogue with the U.S. policy community to advance informed strategies for managing disaster risks.

In many instances, reducing the impacts of disasters ultimately requires actions beyond the purview of the Federal government. The adoption of zoning laws, building codes, and other actions that can build resilience within communities are rightly vested in state and local authorities. In these instances, the most important roles of the Federal government are in research and development (R&D) that underpin technological innovations and in communicating the benefit of such actions. The SDR, and its working groups, are important mechanisms for the Federal government to perform these essential elements of developing a more disaster-resilient America.

The overarching philosophy of the SDR is to examine R&D needs for specific types of disasters within an all-hazards view. Accordingly, basic research on the resilience of structures to wind are coordinated with similar studies related to flooding and storm surge because all three phenomena commonly occur together in hurricanes or severe storms. Likewise, the end-to-end

---

[1] The term "technological disasters" refers to accidental releases of hazardous substances, such as an oil or toxic chemical spill.

aspects of hazards and disasters are considered as a whole; basic research on natural processes that cause disasters is linked to risk assessment, preparedness, and the economic and social impact of disasters. The primary goal of hazard research is to reduce loss of life and property and therefore hazards must be viewed holistically.

Specifically, the SDR facilitates U.S. Government and private/academic activities to reduce vulnerability to natural and technological hazards through:

- Coordinating national research goals and activities for Federal research related to natural and technological hazards and disasters;
- Identifying and coordinating opportunities for the U.S. Government to coordinate and collaborate with state, local, and foreign governments, international organizations and private/academic/industry groups;
- Facilitating the identification and assessment of risks;
- Providing information to the President and Congress to summarize relevant resources and work within SDR agencies;
- Providing information to the Administration and Congress in response to current disaster situations;
- Working with public and private sector policy development bodies;
- Promoting disaster reduction practices;
- Facilitating the exploitation of dual-use systems and fusion of classified and unclassified data streams and research for disaster reduction applications.

The membership and reach of the SDR across the Federal Government is expansive and includes 25 government organizations:

- Department of Defense
  - Networks and Information Integration (NII)
  - United States Army Corps of Engineers
- Department of Energy
- Department of Health and Human Services
  - Centers for Disease Control and Prevention
  - National Institutes of Health
  - United States Public Health Services Commissioned Corps
- Department of Homeland Security
  - Federal Emergency Management Agency
  - United States Coast Guard
- Department of Housing and Urban Development
- Department of State
  - United States Agency for International Development
- Department of the Interior
  - United States Geological Survey
  - The Bureau of Land Management
- Department of Transportation
- Environmental Protection Agency

- Federal Energy Regulatory Commission
- National Aeronautics and Space Administration
- National Geospatial-Intelligence Agency
- National Guard Bureau
- Department of Commerce
    - National Institute of Standards and Technology
    - National Oceanic and Atmospheric Administration
- National Reconnaissance Office
- National Science Foundation
- United States Department of Agriculture
    - United States Forest Service

With such a long list of participating agencies, and an active membership base, the SDR has been a model for interagency coordination. Thus, the SDR was a logical choice to act as the NSTC oversight body for interagency activities on Windstorm Impact Reduction.

II. Actions to date

In October 2004, Congress passed the *National Windstorm Impact Reduction Act*, which originated in the House Science Committee. The bill called for the establishment of the National Windstorm Impact Reduction Program (NWIRP), with the objective of achieving "major measurable reductions in losses of life and property from windstorms." The legislation tasked OSTP with creating a NSTC Interagency Working Group (IWG) on Windstorm Impact Reduction. In January 2005 the NWIRP IWG was convened by the NSTC SDR. The legislation mandated participation by NOAA, NSF, NIST, and FEMA. While those agencies have taken the most active role in the IWG, other Federal entities, such as the Federal Highway Administration, Department of Housing and Urban Development, National Aeronautics and Space Administration and U.S. Army Corps of Engineers, have also participated in the program.

The legislation required that an implementation plan for achieving the objectives of the Program be submitted to Congress. The *Windstorm Impact Reduction Implementation Plan* was submitted to Congress on April 5, 2006 (Attachment 1). The plan outlines how NSTC, in accordance with its responsibility to coordinate science and technology across Federal agencies, can establish a framework to address multi-agency science and technology issues related to windstorm mitigation. Specifically, the plan focuses on identifying research needs that will be an important component of long-term efforts to reduce the impacts of wind hazards. The plan continues to serve as a guide for the IWG as it works to improve coordination of existing wind-related research, and seeks to fill research gaps in understanding, predicting, and forecasting windstorm hazards.

During the formulation of the plan, the IWG reached well beyond the participating Federal agencies to state, county, and city governments, universities, and non-government organizations such as the American Association of Wind Engineers (AAWE), the American Society of Civil Engineers (ASCE), and the Institute for Building and Home Safety (IBHS) for input. The IWG met several times during the creation of the implementation plan and several drafts were circulated throughout the participating agencies. The end product is a useful and comprehensive document.

The legislation also required the development of biennial updates to the implementation plan. The first of these updates was transmitted to Congress on November 20, 2007 (Attachment 2). The biennial update covers Fiscal Years 2005 and 2006 and provides a summary of wind hazard research activities, and progress toward agency goals in each of the NWIRP agencies aimed at understanding, predicting and forecasting wind hazards, assessing and reducing impacts of wind hazards, and promoting preparedness and enhancing community resilience. It also identifies areas of research, compiled by the IWG, that address important national wind hazard problems in the future. The biennial update serves as an excellent resource for understanding each NWIRP agency's contribution to the program. As stated in a June 23, 2008 letter from Dr. John Marburger III to Chairman Gordon, the next biennial report will be submitted to Congress in fall 2008 or spring 2009 (Attachment 3).

III. Grand Challenges for Disaster Reduction

As noted above, the IWG on Windstorm Impact Reduction operates under the auspices of the SDR. Given its close link to the SDR, the NWIRP follows the same philosophical underpinnings established in the SDR's February 2008 report *Grand Challenges for Disaster Reduction* (Attachment 4). These challenges are as follows:

Grand Challenge #1—Provide hazard and disaster information where and when it is needed
Grand Challenge #2—Understand the natural processes that produce hazards
Grand Challenge #3—Develop hazard mitigation strategies and technologies
Grand Challenge #4—Recognize and reduce vulnerability of interdependent critical infrastructure.
Grand Challenge #5—Assess disaster resilience using standard methods
Grand Challenge #6—Promote risk-wise behavior

The *Grand Challenges for Disaster Reduction* report was released on February 1, 2008 and is a ten-year strategy that is focused on the application of science and technology to enhance community resilience to disasters and create a more disaster-resilient Nation.

To implement this ten-year strategy, the 25 Federal departments and agencies of the SDR worked together to identify specific actions that they, in collaboration with state and local governments, as well as individuals and institutions in the private sector, must take in order to meet the Grand Challenges. The resulting framework of prioritized Federal science and technology actions, which is compiled in 14 hazard-specific implementation plans, can help increase the Nation's disaster resilience by guiding future investments.

Of the 14 hazard-specific implementation plans, three are directly linked to the IWG on Windstorm Impact Reduction; Tornados (Attachment 5), Hurricanes (Attachment 6) and Winter Storms (Attachment 7). The IWG helped guide the creation of these plans.

III. Overview of agency work in the area of wind hazards

The *Windstorm Impact Reduction Implementation Plan* described four major themes for wind hazard research:

- Understanding, Predicting, and Forecasting
- Assessing Impacts
- Reducing Impacts
- Preparedness and Enhancing Community Resilience

Agency activities in these four areas are performed in the context of each agency's mission and consistent with their research practices. These activities are focused in several areas: continued improvement in windstorm prediction; local, state, regional and federal coordinated research response capabilities following wind hazard events, including field validation and data collection capabilities for buildings, critical infrastructure and essential facilities; windstorm damage and loss estimation modeling tools; and standards and technologies that will enable cost-effective, state-of-the-art windstorm-resistant provisions to be adopted as part of state and local building codes. The following discussion outlines ongoing efforts to address the need for improvement in these areas, organized by agency.

National Science Foundation

The National Science Foundation (NSF) supports unsolicited research proposals related to NWIRP topics ranging from atmospheric sciences research that is concerned with the physics of hurricane, tornado, and thunderstorm formation, to engineering programs focused on improving the performance of structures against wind loads, to social science programs devoted to societal preparedness and response to natural disasters. Although these proposals are selected through the peer review process under programs intended to advance research in myriad areas and not just hurricanes and winds, the NSF portfolio of projects have collectively made important progress in each of four focus areas defined above.

For example, significant progress in documenting and analyzing the damage caused to civil infrastructure by wind and hurricane driven storm surge was made by NSF-supported investigators as a result of awards made immediately after Hurricanes Katrina and Rita. Social science topics under continued investigation include evaluating preferences for rebuilding plans post-Katrina, assessing public health impacts of disasters, decision-making in displaced populations, and examining factors associated with compliance to Katrina mandatory hurricane evacuation orders in seven coastal Louisiana parishes.

NSF funds research that often directly leads to changes in building code revisions through development of new materials and/or design methodologies. New awards directly related to design of wind-resistant structures include five that have been made through the Hazard Mitigation and Structural Engineering Program in the Engineering Directorate during the past 12 months. One of these, "Hurricane Wind Simulation and Testing to Develop Damage Mitigation

Techniques,"[2] will develop a cost-effective, light, strong, ductile, and non-intrusive roof-to-wall connection system using high performance fiber composite materials to improve hurricane resiliency of residential buildings. A second one, "Performance Based Wind Engineering: Interaction of Hurricanes with Residential Structures,"[3] is expected to improve design methods for wood frame buildings through the use of the performance-based design approach. Research results will be disseminated through the ASCE/SEI committees in which the Principal Investigator is involved.

Understanding, Predicting and Forecasting

Over the past two years, research in atmospheric sciences has yielded a better understanding of atmospheric dynamics of straight-line winds and improved knowledge of the fundamental physics that control hurricane intensity, wave dynamics during hurricanes, and the impact of externally and internally modulated convection on tropical cyclone evolution.[4] Understanding the hazard risk associated with extreme hurricane events is also being studied. Detecting synoptic-scale precursors of tornado outbreaks[5] is the objective of one investigation. Another project is studying tornadic storms with Doppler Polarimetric Radar.[6]

Assessing the impacts of wind hazards

Shortly after Hurricane Katrina struck the Gulf States, 29 small grants were awarded for reconnaissance studies aimed at documenting their effects and preserving highly perishable data. Two of these studies, on the performance of the levee system, were expanded in scope to include engineering analyses of failed sections of the levees and proposed repair and replacement strategies. Development of instrumentation for the observational studies of the effects of atmospheric winds on structures near the ground was also undertaken. Another of these projects investigated large coastal bridge performance in a hurricane environment. Collection of perishable data on wood-frame residential structures in the wake of Hurricane Katrina was also undertaken. Studies were conducted to better understand the response of typical bridges to hurricanes and to assessing risk for long-span bridges. The determination of storm surge effects on levees and the simulation of non-linear water waves during hurricanes were the subjects of other investigations. In order to better understand the impacts of hurricane disasters, construction material requirements for rebuilding New Orleans are being investigated and documented. Improving glass performance during wind storms and the modeling response of tall buildings to straight line winds are important for understanding the impacts to wind hazards.

Social science topics under investigation include evaluating preferences for rebuilding plans post-Katrina, assessing public health impacts of disasters, and decision making in displaced populations. In particular, one project is examining factors associated with compliance to Katrina mandatory hurricane evacuation orders in seven coastal Louisiana parishes.

---

[2] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0727871
[3] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0800023
[4] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0514199
[5] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0527934
[6] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0532107

Reducing Impacts of Wind Hazards
Resistance of existing wood roof structures and retrofit schemes is currently being studied to better understand how best to construct more resistant structures in the future. This type of damage accounts for a significant portion of the damage caused by hurricanes and straight line winds each year. In addition, a better understanding of the impact of hazard events on soils, infrastructure, and the submerged environment is required. A project entitled "The Effect of Katrina on Submerged Geotechnical Systems - Underwater Evaluation of Sediment-Structure-Storm Interaction" will provide important data on these important parts of the urban infrastructure. Another project that is vital to the energy supply is focusing on assessment of damage to underground tanks in New Orleans in the aftermath of Hurricane Katrina. Electric Utility Damage from Hurricane Katrina is also under investigation.

Preparedness and Enhancing Community Resilience
Instructional materials for K-12 students are being developed to enhance preparedness among children. Also, information technologies are being developed to assist individuals in adapting to evacuation. Social networks are being studied to understand the role they might play in early warning strategies and subsequent compliance. Improving hurricane intensity forecasting is important to increase societal compliance and evacuation plans and orders, but the public must also be educated to understand risk and appropriate behavior to ensure their safety. Two studies are underway to better understand and improve evacuation procedures. Two projects have been funded for analyzing multi-organizational networks and their roles in hazard mitigation. Ten projects are underway that are investigating various tools that might be useful for building community resilience to wind hazards. One of these projects is examining how preferences for rebuilding plans are being made after Hurricane Katrina.[7] Another one is studying "The Parallel Strengths and Weaknesses of the Civil Society and the State: The Example of Katrina Survivors."[8] "Cyberinfrastructure Preparedness for Emergency Response and Relief: Learning the lessons from Hurricane Katrina" is the focus of another investigation.[9]

The majority of NSF support for wind hazard R&D activities is in response to unsolicited proposals, although some support is provided through the National Center for Atmospheric Research (NCAR) and the Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA). NSF is also sponsoring a joint solicitation with NOAA on Communicating Hurricane Information. NSF estimates that $6.7 million will be spent on wind hazard R&D in FY 2008.

National Oceanic and Atmospheric Administration

NOAA activities and progress during the past two years can be divided into six categories: 1) development of plans; 2) provision of data of use for wind hazard reduction; 3) development of decision support tools and analyses of relevance to wind hazards; 4) understanding and predicting weather conditions producing wind damage; 5) creation of new facilities for improving our knowledge and prediction of wind hazards; and 6) education and outreach.

---

[7] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0554987
[8] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0555113
[9] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0638561

Development of plans
NIST and NOAA jointly developed a cooperative plan on Hazard-Resilient Communities, and are moving forward with the storm surge component of that plan. NOAA is represented on the U.S.-Japan Panel on Wind and Seismic Effects. This panel encourages exchange of information between the two countries and is completing a joint project on bridge stay flutter. It is also proposing a workshop to exchange information between wind structural engineers and meteorologists who work on wind issues to determine the needs of and opportunities presented by the two communities working closely together. The workshop is anticipated to occur within the next year.

Providing data of use for wind hazard reduction
During FY 2004, several extreme turbulence (ET) probes were developed and successfully tested in actual hurricanes. These probes hold promise for very high spatial and temporal resolution measurements of winds on the immediate exterior of structures. In cooperation with NOAA, the Florida and South Carolina Sea Grant deployed portable towers measuring winds during Hurricanes Charley, Frances, Ivan, Katrina, and Rita. These data are useful for "nowcasts" of the winds and to duplicate wind tunnel measurements. The Shared Mobile Atmospheric Research and Teaching Radars (SMART-R), the result of a cooperative effort between the University of Oklahoma and NOAA, have been used in hurricane landfall deployments, and have been upgraded to deliver their data directly to forecast offices in real time. The stepped frequency microwave radiometer is now deployed on both research and operation aircraft for much improved surface wind and vertical wind profiles over water within hurricanes and they are now used in NOAA's operational hurricane model and for real-time hurricane intensity analysis.

Decision support tools and analysis for wind hazards
NOAA has been working with the state of Florida on a Public Hurricane Loss Projection Model to develop wind-dependent vulnerability functions for building retrofit guidance. The NOAA hurricane wind (H*WIND) analysis was used to validate this model. A stochastic model is being used to simulate 55,000 years of hurricane tracks for a wind demonstration project, conducted with NIST, to test wind and storm surge risk maps in a few selected coastal areas. The U.S. Army Corps of Engineers and NOAA completed a post-Hurricane Katrina, Charley, Frances, Ivan, and Jeanne 1-km resolution wind field analysis using the H*WIND product and data that were not available in real time. NOAA's National Hurricane Center introduced its new experimental wind-speed probability forecast in time for the 2006 hurricane season to map out several predicted wind-speed thresholds.

Understanding and predicting weather conditions producing wind damage
NOAA continues to gather field data on hurricane inner core dynamics to better understand intensity changes. During the past two hurricane seasons, NOAA, with the Office of Naval Research, has been measuring the heat and momentum exchange between the atmosphere and ocean within hurricanes to better parameterize this exchange in hurricane prediction models.[10, 11] Preliminary testing of these new parameterizations in NOAA's operational hurricane model has improved hurricane intensity predictions. NOAA tested a new hurricane model during the 2006 hurricane season for operational application next season. It is coupled with an ocean model and has a nested and movable grid.

The President's 2009 Budget includes nearly $20 million for hurricane-related increases across NOAA, including modeling improvements on forecasts and storm surge and research into ocean vector winds and coastal inundation. The 2009 Budget also includes an increase of $242 million for the GOES-R satellite system, which is a critical component of NOAA's hurricane monitoring.

Creating new facilities for improving our knowledge and prediction of wind hazards
The new National Weather Center in Norman, Oklahoma opened its doors during the summer of 2006. It consists of the South Research Campus of the University of Oklahoma, the NOAA Norman forecast office, the Storm Prediction Center, and the National Severe Storms Laboratory. This facility also features the Hazardous Weather Testbed, which performs research and development to improve prediction of hazardous winds.

Education and outreach

- NOAA's Louisiana Sea Grant program has developed fact sheets that include information on building codes, where and how to rebuild, and how to determine if a contractor is following state and federal regulations. It has been distributed to parishes and is available on the Internet. The program has also sponsored seminars on storm preparedness and has provided information on building codes and zoning practices.
- NOAA's Texas Sea Grant Program (Texas A&M) has been evaluating the Texas Mitigation Plan, which includes construction codes.
- The North Carolina Sea Grant (North Carolina State in collaboration with Oregon State) developed a break-away wall design for 125-mph winds and 1.5-ft waves, which has been adopted by the American Society of Civil Engineers.
- The South Carolina Sea Grant (Clemson) has developed low-cost methods for reducing storm damage, including strengthening roofs and shutters which have been adopted by a Sun City developer.
- There is now a "hazards house" in Charleston, SC, that helps educate the public on hazard-resilient building and retrofitting techniques, including those that mitigate wind effects.
- NOAA has prepared material for a documentary on how to stay safe in high winds, including how to improve housing construction to resist damage and the appropriate design for safe rooms. The documentary will be featured on the Discovery Channel.
- NOAA held its first Weather Partners open house in Norman, OK, for approximately 1000 visitors. Wind risk to structures was a prominent theme for discussion.
- NOAA organized a training session at the National Hurricane Conference on hurricanes and public health. During the session, a representative from the Institute of Building and Home Safety delivered a presentation on the resilience of public health facilities against structural hazards. Key structural components included window strength, exterior cladding, roof edging, and vulnerability of roof type and roof mountings. The participants then critically evaluated a simulated hurricane scenario.

National Institute for Standards and Technology

NIST research over the past two years has focused on gaining an understanding of wind hazards to the built environment and developing predictive technologies and mitigation strategies to enhance disaster resilience to wind hazards.

Extreme Wind Databases
To facilitate use of Automated Surface Observing Station (ASOS) wind data for structural engineering purposes, NIST developed procedures and software for (a) extraction of peak gust wind data from archived ASOS weather reports, (b) extraction of thunderstorm observations from archived weather reports, (c) classification of wind data as thunderstorm or non-thunderstorm to enable separate statistical analyses of these distinct types of winds, and (d) construction of data sets separated by specified minimum time intervals to ensure statistical independence. Estimates showed that, at these stations, thunderstorm wind speeds dominate the extreme wind climate to the extent that non-thunderstorm wind speeds can be disregarded in the analysis. Using such records it is possible to obtain realistic probabilistic descriptions of the wind climate at stations where both types of wind occur. The software, data, and literature are available at www.nist.gov/wind.

Advanced Computational Tools for Determining Realistic Wind Loads in the Built Environment
NIST has developed software for analyzing wind effects on rigid, gable-roofed buildings, and flexible high-rise buildings using the database-assisted design methodology. Database-Assisted Design (DAD) is a unified framework for analysis and design of buildings for wind loads that makes direct use of pressure-time histories measured at a large number of pressure taps on wind tunnel models. Local climatological information can be used in conjunction with the measured pressures to obtain estimates of peak wind effects with specified return periods for use in structural design. DAD offers more accurate estimation of peak wind effects than simplified procedures that are now used, which paves the way for more risk-consistent designs. The software, data, and literature are available at www.nist.gov/wind.

Methodologies for Predicting Ultimate Structural Capacities and Estimating Safety Margins
The design of many low-rise metal buildings in the U.S. is based on the ASCE 7-93 Standard and the use of Allowable Stress Design (ASD). NIST used the nonlinear database-assisted design technique to assess the degree of safety of a typical low-rise portal frame industrial structure designed in accordance with ASCE 7-93 and ASD as compared to the provisions of the ASCE 7-02 Standard. NIST has found that the frame being considered satisfies all ASCE 7-02 requirements with respect to wind loading but that its safety level is relatively low and could be improved substantially at very low cost.

Assessing the Performance of Structures in Wind Disasters
NOAA's National Weather Service implemented the enhanced Fujita Tornado Intensity Scale on an operational basis in February 2007. The enhanced Fujita scale is based upon observations by a NIST researcher as part of a reconnaissance team deployed following the 1997 Jarrell, TX tornado and subsequent technical work performed by Texas Tech University with funding and technical oversight by NIST. The more realistic wind speeds associated with the enhanced scale

will allow the use of routine standard provisions for the safe design of buildings under most tornadoes occurring in the U.S.

After Hurricane Katrina and Hurricane Rita, NIST assembled a team of experts to conduct a reconnaissance of the status of buildings, physical infrastructure, and residential structures in the New Orleans area, coastal Mississippi, and Southeast Texas. NIST documented its findings on the environmental conditions (e.g., wind speeds, storm surge elevations, and flooding) and on the performance of structures in the study areas in its final report issued in June 2006. The report includes 23 recommendations in three groups: 1) immediate impact on practice for rebuilding, 2) standards, codes, and practices, and 3) further study of specific structures or research and development.

Technical Basis for Improved Codes and Standards

Estimates of the World Trade Center (WTC) towers' response to wind by two North American wind engineering laboratories differed from each other by almost 50 percent. A NIST investigation indicated that those differences reflected discrepancies between the respective estimates of the wind speeds and the respective modeling of directional interaction between wind speeds and aerodynamic/dynamic response of the building. NIST analyzed the role of risk-consistent probabilistic definitions of peak wind effects in developing safety margins for inclusion in codes and standards.

U.S.-Japan Panel on Wind and Seismic Effects

NIST chairs the U.S.-Japan Joint Panel on Wind and Seismic Effects and NIST staff actively participates in the Panel and its wind engineering task committee. The Panel provides an effective mechanism for the exchange of technical data and information, the exchange of researchers, and the coordination of joint research on topics of mutual interest to the U.S. and Japan.

Wind-related Storm Surge

Hurricane Katrina demonstrated that (1) hurricane storm surge can substantially exceed heights defined by existing flood hazard maps, and (2) there is a lack of a methodology for assessing the risk associated with different joint hurricane wind speed/surge height events that can be used for establishing risk-consistent design criteria for structures in coastal regions exposed to the combined effects of hurricane wind and storm surge. Such methodology must take into consideration the effects of local topography and bathymetry, on which storm surge at any specific location is highly dependent, as well as hurricane parameters such as track, forward speed, wind speed, and central pressure. NIST/BFRL is working in collaboration with NOAA's National Weather Service, Office of Atmospheric Research and National Hurricane Center, and the University of Florida, to develop this methodology. NIST and NOAA have developed the basic methodology using the Florida Public Hurricane Loss Model and demonstrated the methodology for a small number of stations in the Tampa Bay area. The objective of this work is to develop this methodology such that it can be used to estimate the joint probability for wind and storm surge events (including wave action) along the U.S. coastline and provide the technical basis for improving the hazard criteria used for application of flood resistant design provisions.

Federal Emergency Management Agency

FEMA supports a variety of NWIRP-related activities including risk assessment, windstorm-related data collection and analysis, mitigation promotion and public outreach, and hurricane program coordination.

Risk Assessment
FEMA developed HAZUS-MH, a risk assessment program that analyzes potential losses from floods, hurricane winds and earthquakes. HAZUS-MH combines current scientific and engineering knowledge with the latest GIS technology to produce hazard-related damage estimates before or after a hazard event. The current version of the software program – HAZUS-MH MR2 – allows communities to access a risk assessment tool that can serve as a basis for mitigation planning and policy development, emergency preparedness, and emergency response and recovery exercises.

Data Collection and Analysis
After major natural hazard events, a Mitigation Assessment Team - or MAT - study may be conducted to perform engineering analyses, assesses damage, determine the causes of structural failures and successes, and prepare recommendations regarding construction codes and best practices. Communities and construction professionals, in turn, use MAT information and recommendations to plan for, and reduce damages from, future events. *A telling MAT conclusion following Hurricane Katrina: buildings that experienced substantial structural damage from Katrina typically were built before building design and construction professionals adequately considered wind effects.*

Promoting Mitigation – Education and Public Outreach
To educate communities about mitigation and the steps they can take to reduce their vulnerabilities to natural hazard events, FEMA and the MAT continue to develop first-of-its-kind construction advice guidance. Widely disseminated, FEMA's mitigation guidance provides Gulf coast residents with engineering recommendations and foundation solutions for rebuilding; many of which are being incorporated into local reconstruction efforts. Additionally, the MAT publication *FEMA 550 Residential Construction for the Gulf Coast: Building on Strong and Safe Foundations* provides homeowners, builders, and design professionals with prescriptive, pre-engineered foundation solutions, cost information, and guidance on choosing and building disaster-resistant foundations.

Hurricane Program Coordination
FEMA and NOAA work together to improve the Nation's hurricane evacuation planning. NOAA research produces improved hurricane intensity predictions which, in turn, help FEMA and emergency managers across all governmental levels with critical planning, evacuation, response, and recovery decisions. Since 2004, despite resource and funding limitations, the NWIRP partnership has collaborated to: enhance knowledge and information on severe winds; investigate the wind resistance of buildings and structures; develop improved tools for assessing

wind hazard losses; improve public awareness of wind hazards and related mitigation; and enhance wind hazard-related evacuation planning and guidance.

While not specifically identified as NWIRP funding, FEMA's FY 2004 -2008 budgets, have funding in the Mitigation Directorate, Risk Reduction Division that has been characterized as meeting the basic goals of the NWIRP. The funding level for FY 2004- FY 2008 was between $200 - 350K per year for a total of approximately $1.5 million. In FY 2009 FEMA anticipates $200 - 250K of funding. Specific areas of activity include:

- FEMA support for wind-resistant national Model Building Codes and Consensus Standards;
- FEMA support for the development of national Wind Shelter guidance and standards; and ongoing support for hurricane evacuation studies

Federal Highway Administration

Understanding, Predicting and Forecasting Wind Hazards
The FHWA Office of Infrastructure R&D continuously monitors winds at the sites of three major long-span, cable-supported bridges to establish and characterize site-specific wind conditions and the responses of the bridges. All sites are relatively near the coastline with one in Louisiana, another in Delaware, and the third in Maine. A new site will be added monitoring the Bill Emerson Bridge at Cape Girardeau, Missouri. The engineering data collected at these sites provides valuable input into design of new structures.

Assessing the Impact of Wind Hazards
The FHWA Office of Infrastructure R&D has continuously monitored the wind environment and detailed response of three major long-span, cable-supported bridge structures to evaluate their wind performance and wind resistance with one more site being added in 2008. The Computational Fluid Dynamics (CFD) model UABRIM is being enhanced by implementation of unstructured and adaptive grids for use in simulating the interaction between wind and structures such as large bridges. Tests have been completed in the FHWA's small wind tunnel at the Turner Fairbank Highway Research Center using evolving Particle Image Velocimetry (PIV) technology to study wind flow fields around and compute wind forces on several representative bridge deck sections. This small wind tunnel has been automated for more efficient operation.

The FHWA Office of Operations continued activities under the Road Weather Management Program, which seeks to develop and promote effective tools for observing and predicting the impacts of weather on the roads, and to alleviate these weather impacts. As part of the program, the Clarus Initiative has continued to conduct activities to develop and demonstrate an integrated surface transportation weather observing, forecasting and data management system, and to establish a partnership to create a Nationwide Surface Transportation Weather Observing and Forecasting System. The Initiative Coordinating Committee (ICC) held its annual meeting in August 2008. Phase 3 of the Clarus Regional Demonstration will be initiated shortly showcasing how road and weather observations from the Clarus System can be used to develop and deploy more advanced road weather management solutions for transportation operations.

Reducing the Impact of Wind Hazards
The FHWA Office of Infrastructure R&D continues to conduct research to prepare a synthesis report on Wind Load Criteria for Cable Supported Structures. Complementary research has also been initiated to prepare a synthesis report on User Comfort and Serviceability Criteria for Wind Loading. Research has continued on the study of wind- and wind/rain-induced vibration of bridge stay cables a major issue for bridge owners. A second version of the guidelines document has been developed for the aerodynamic design of bridge stay cables.

Preparedness and Enhancing Community Resilience
The FHWA Office of Infrastructure R&D, together with the Missouri Department of Transportation, organized and held the 2nd National Workshop on Wind-Induced Vibration of Cable-Stayed Bridges in April 2006. This workshop served to disseminate the latest information on the mitigation of wind-induced vibrations to state bridge engineers and design consultants. FHWA has been participating in international conferences such as the 7th International Symposium on Cable Dynamics in Vienna Austria in 2007, and the 7th Colloquium on Bluff Body Aerodynamic and Application in 2008 in Milan, Italy to transfer to research knowledge. Further, FHWA continues to assist State DOTs to solve wind and wind induced issues as they arise.

IV. Conclusion

Measurably reducing losses of life and property from windstorms, including hurricanes, tornadoes, and seasonal storms, remains a high priority. As pointed out by the variety of reports available on the subject, such reduction will be predicated on improving the ability to predict the occurrence, location, and magnitude of windstorms with sufficient accuracy to allow the public and emergency managers to take appropriate measures and to increase the resiliency of our communities by constructing wind resistant buildings, highways, and other key portions of infrastructure. The Federal agencies support robust research programs in these areas, and have made significant progress in making the results of this research more widely available. The benefits of this improved understanding will not be fully realized, however, until it is incorporated more completely into actions at the state and local level, both through building codes, design standards, and construction practices.

The importance of developing resilient communities will likely be further underscored as the Earth's changing climate will likely make historic trends in storm frequency and intensity a less reliable predictor of future conditions. Adaptation to a warming climate and accompanying changes in the nature of wind-related hazards will create a greater impetus for Federal efforts to understand and predict wind hazards on a time scale longer than the typical weather forecasts available today, so that knowledge can inform the construction of buildings, bridges, and other components of the physical infrastructure intended to function safely for the next 30 to 50 years.

The NWIRP partnership must keep working with other Federal agencies, State and local governments, academia, and the private sector to help our Nation's communities understand and plan for their risks and take steps to reduce them and must find ways to address critical NWIRP issues in an environment of limited resources.