STRENGTHENING WINDSTORM HAZARD MITIGATION: AN EXAMINATION OF PUBLIC AND PRIVATE EFFORTS

FIELD HEARING

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February 9, 2004

STRENGTHENING WINDSTORM HAZARD MITIGATION: AN EXAMINATION OF PUBLIC AND PRIVATE EFFORTS

MONDAY, FEBRUARY 9, 2004

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE,
Washington, DC.

The Committee met, pursuant to call, at 1:30 p.m., at the Merket Alumni Center, Texas Tech University, Lubbock, Texas, Hon. Randy Neugebauer, presiding.

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

Strengthening Windstorm Hazard Mitigation: An Examination of Public and Private Efforts

Monday, February 9, 2004
1:30 PM
Merket Alumni Center, Texas Tech University, Lubbock, TX

Witness List

Dr. Charles Meade
Primary author
RAND study, "Assessing Federal Research Developments for Hazard Loss Reduction"

Dr. Ernst Kiesling
Professor of Civil Engineering
Texas Tech University

Dr. Bogusz Bienkiewicz
Professor, Department of Civil Engineering
Colorado State University

Mr. Bryan Shofner
President
Shofner and Associates Insurance Agency

HEARING CHARTER

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

Strengthening Windstorm Hazard Mitigation: An Examination of Public and Private Efforts

MONDAY, FEBRUARY 9, 2004
1:30 P.M.–3:30 P.M.
MERKET ALUMNI CENTER,
TEXAS TECH UNIVERSITY,
LUBBOCK, TEXAS

1. Purpose

On Monday, February 9, 2004, at 1:30 p.m., the House Science Committee will hold a field hearing to examine the status of windstorm hazard mitigation in the United States, and to consider the role of federal research and development in windstorm hazard reduction.

2. Witnesses

Dr. Charles Meade is a senior physical scientist with the RAND Corporation's Science and Technology Policy Institute in Washington, DC. He is the primary author of *"Assessing Federal Research Developments for Hazard Loss Reduction,"* a study prepared for the White House Office of Science and Technology Policy in 2003.

Dr. Ernst W. Kiesling is a Professor of Civil Engineering at Texas Tech University. Dr. Kiesling has 37 years of teaching, research, and administrative experience at Texas Tech University, including serving as Chairman of the Civil Engineering Department from 1969 to 1988. Dr. Kiesling was the first to develop an "in-residence" tornado shelter, providing occupant protection during tornadic events. The research provided the basis for a Federal Emergency Management Agency (FEMA) publication on in-residence shelter design.

Mr. Bryan Shofner is President of Shofner & Associates Insurance Agency in Lubbock, Texas. Mr. Shofner was named "Young Agent of the Year" in 2001 by the Independent Insurance Agents of Texas. Mr. Shofner has been a longtime member of his local, State, and national independent insurance agents associations, including serving as President of the Lubbock Association of Insurance Agents.

Dr. Bogusz Bienkiewicz is a Professor of Civil Engineering at the Colorado State University Wind Engineering and Fluids Laboratory. Dr. Bienkiewicz is also the Vice President of the American Association for Wind Engineering, Secretary of the American Society of Civil Engineers Committee on Wind Effects, and Co-chairman of the International Wind Engineering Forum.

3. Overarching Questions

The hearing will address the following overarching questions:

1. How vulnerable is the built environment in the United States to windstorm hazards? What are some of the top opportunities for, and primary barriers to, reducing these vulnerabilities?
3. What is the size, structure, and focus of federal wind hazard mitigation efforts, particularly with regard to research and development?
3. What gaps in data exist with regard to our knowledge and understanding of windstorm hazards, and how could the overall wind hazard mitigation portfolio be refocused or otherwise strengthened to improve mitigation in the United States?
4. How can non-federal entities such as the insurance industry and State and local governments contribute to, and benefit from, improved wind hazard mitigation?

4. Brief Overview

- The United States currently sustains several billion dollars each year in property and economic losses due to windstorms. While estimates of annualized windstorm damages are highly variable and limited in scope, the National Weather Service estimates that between 1995 and 2002, hurricanes, tornadoes, and thunderstorm winds caused on average $4.5 billion in damage per year. The American Society of Civil Engineers has estimated windstorm damages to be in excess of $5 billion per year.
- The most powerful hurricane in the last century to hit the United States was Hurricane Andrew, in August of 1992. It caused 58 deaths and approximately $27 billion in damages. In addition, more than one million people were evacuated from Southern Florida because of the storm.
- A variety of cost-effective windstorm hazard mitigation measures exist, and many more are undergoing research and development. It is unclear to what extent these mitigation technologies have been adopted, but it is generally agreed that they have been under-utilized, and that significant improvements in the wind resistance of buildings and other structures will not be achieved without improved incentives at the local and individual level. This fact, combined with growing populations in coastal areas particularly susceptible to major windstorms, has led to substantial increases in the overall windstorm vulnerabilities.
- Federal windstorm hazard mitigation efforts span several agencies, including the Federal Emergency Management Agency (FEMA), National Institute of Standards and Technology (NIST), National Oceanographic and Atmospheric Administration (NOAA), National Science Foundation (NSF), and the Department of Energy (DOE). Evaluations of the size, scope, and effectiveness of these mitigation efforts have found significant room for improvement. For example, a 1999 report by the National Academy of Sciences found that: ". . .there is still a lack of leadership, focus, and coordination of wind-hazard mitigation activities across all agencies, and funding for research and development specifically targeting wind-hazard reduction issues is insufficient."

5. Background

Hurricanes and Tornadoes

High winds can easily destroy poorly constructed buildings and mobile homes. Hurricanes can reach constant wind speeds greater than 155 mph and extend outward as far as 400 miles. While the National Weather Service is able to detect hurricanes days before they make landfall, predicting when, where, and with what force a hurricane will hit remains an inexact science.

Tornadoes generally occur near the trailing edge of a thunderstorm, though they are also often produced by hurricanes. Tornado winds can reach up to 300 mph and can be powerful enough to lift homes off foundations. Tornadoes are much more difficult to detect than hurricanes with an average lead-time for warnings of only 12 minutes. This makes evacuation nearly impossible, a factor that led to the development and implementation of in-residence tornado shelters, developed from research performed at Texas Tech University.

Since 1950, tornadoes have claimed over 4,400 lives. Texas has been particularly vulnerable, averaging 124 tornadoes each year—more than double the average of any other state. On May 11, 1970, a tornado ripped through downtown Lubbock, Texas, killing 26 people, injuring at least 1,500 more, and causing more than $530 million in damage.

While the Federal Government does not maintain a comprehensive windstorm loss database, the National Weather Service does compile damage estimates that demonstrate the tremendous costs of windstorms (Table 1). Also, the insurance industry maintains separate loss databases that measure damage to insured property. However, according to *"Disasters by Design: A Reassessment of Natural Hazards in the United States,"* a 1999 report by the National Academy of Sciences, insurance industry data may represent only a small percentage of total losses because many property owners do not buy coverage against hurricanes and other natural hazards.

Table 1. National Weather Service Estimates of Windstorm Impacts (1995-2002)

	Fatalities			Injuries			Total Damages (In millions of $)		
Year	Tornadoes	Hurricanes	T-storm Winds	Tornadoes	Hurricanes	T-storm Winds	Tornadoes	Hurricanes	T-Storm Winds
2002	55	51	17	968	346	287	802.1	1382.4	344.5
2001	40	24	17	743	7	341	637.5	5190.5	378.8
2000	41	0	25	882	1	296	430.5	8.2	304
1999	94	19	29	1842	10	325	1998.2	5068.8	388.7
1998	130	9	41	1868	77	860	1736.2	4127.9	1597.3
1997	67	1	37	1033	32	425	736.5	875.4	242.1
1996	25	37	23	705	22	335	732.1	1787	452.8
1995	30	17	38	650	112	473	410.8	5932.3	745.1

With more people than ever before living near coastlines, vulnerability to wind hazards in the U.S. is steadily increasing. Already, more than one in six Americans live in a county that lies next to the eastern Atlantic or Gulf of Mexico coast. In addition, the coastal population is growing rapidly, particularly from Texas through the Carolinas. In popular resort areas that are common along the coastline, numbers often swell even further when holiday, weekend, and vacation visitors arrive. These large and increasing populations have resulted in substantial increases in buildings and infrastructure in high-risk coastal areas that are also vulnerable to windstorms.

Federal Windstorm Hazard Mitigation Efforts

The size and scope of federal investments in windstorm hazards research and development (R&D) is generally agreed to be in the range of a few million dollars, though specific numbers are hard to come by, in part because of the fragmented and uncoordinated nature of these efforts. Agencies contributing to this effort include FEMA, NOAA, NIST, NSF, and DOE.

The bulk of the windstorm hazard funding is directed toward fundamental research and development into the atmospheric and meteorological aspects of windstorms, contributing to a greater understanding of weather-related phenomena, but generally without specific mitigation applications in mind. A smaller portion of the windstorm hazard research and development effort is directed toward structural and engineering aspects of buildings and infrastructure impacted by windstorms. In a 1999 report, the National Academy of Sciences recommended that: "The Federal Government should coordinate existing federal activities and develop, in conjunction with state and local governments, private industry, the research community, and other interested stakeholder groups, a national wind-hazard reduction program. Congress should consider designating sufficient funds to establish and support a national program of this nature."

Unfortunately, simply developing technical solutions will not reduce vulnerability to wind hazards. FEMA and the insurance industry have both determined that improving the wind resistance of buildings will only be achieved when there is a demand for wind-resistant construction by homeowners. Solving the wind-vulnerability problem will not only require coordinated work in scientific research and technology development, but education, public policy, the behavioral sciences, and technology transfer as well.

6. Questions for Witnesses

The witnesses were asked to address the following questions in their testimony:

Dr. Meade

- What regions of the country and characteristics of the built environment are most vulnerable to windstorm hazards? Are these vulnerabilities increasing or decreasing, and why? What are some of the opportunities for, and primary barriers to, reducing these vulnerabilities?
- Approximately how much money does the Federal Government spend per year on wind hazard mitigation research and development? Where is this effort currently focused (i.e., direct vs. indirect research, engineering, economic, meteorological, etc.)? Where are the primary gaps with regard to our knowledge and understanding of windstorm hazards? How could the federal wind hazard research and development portfolio be refocused or otherwise strengthened to improve mitigation in the United States?

Dr. Bienkiewicz and Dr. Kiesling

- What regions of the country and characteristics of the built environment are most vulnerable to windstorm hazards? Are these vulnerabilities increasing or decreasing, and why? What are some of the top opportunities for, and primary barriers to, reducing these vulnerabilities?
- What are some of the processes that are in place for transferring new technologies to government agencies and the private sector for implementation? What role do the research activities at Texas Tech University and Colorado State University play in implementation of new mitigation techniques?
- What steps could be taken to strengthen the federal wind hazard research and development portfolio in the United States, particularly with regard to planning, coordination, and focus within the research and development portfolio?

Mr. Shofner

- How would you characterize the size and focus of ongoing wind hazard mitigation research and development being performed by the insurance industry? To what extent do insurance industry research efforts build on research done by universities or the government, and vice-versa? How does the insurance industry work with Federal, State, and local governments to share data that may help contribute to windstorm hazards reductions?
- Approximately how much damage do wind hazards cause in the United States on an annual basis, and are these damages broken down by variables such as building types, structural characteristics, and geography? What types of damage are taken into account in compiling these damage estimates, and what types are not included? What data gaps exist with regard to our knowledge and understanding windstorm hazards?
- What role does the insurance industry play in encouraging implementation of existing mitigation techniques in retrofitting and new home construction? To what extent do insurance policies consider and incorporate incentives for implementation of these mitigation techniques?

Mr. NEUGEBAUER. We will call this hearing to order on *Strengthening Windstorm Hazard Mitigation* for purposes of the examination of public and private efforts.

I want to welcome everyone to this hearing where we will examine the status of windstorm hazard mitigation in the United States and consider the role of federal research and development in windstorm hazard reduction.

On May 11th, 1970, tragedy struck Lubbock, Texas. An F–5 tornado ripped through downtown Lubbock. Twenty-six people were killed, and at least 500 were injured. The tornado had winds estimated in excess of 200 miles per hour and damaged or destroyed a large section of the city, mainly north and east of 19th and University, where we sit today.

And as a little postscript to that, I was at the corner of 22nd and University in a friend of mine's home, but I should have been over on 5th and Avenue Q in my apartment, which was totally destroyed by the tornado, and so I can testify that my person was safe, but my property was not. We are going to be talking about some issues that revolve around that today.

In just a few moments, between 9:35 p.m. and the time that the funnel lifted into the clouds, the tornado devastated the community along an eight and a half mile wide path. It wrought havoc along a track that was one and a half miles wide in downtown Lubbock, to one-fourth mile wide as it passed over the Weather Bureau Office located at the Lubbock Airport. The twister was responsible for $125 million in damage and an estimated 15 square miles of the city either damaged or destroyed.

The National Weather Service estimates that between 1995 and 2002 hurricanes, tornadoes, and thunderstorm winds caused an average of $4.5 billion in damage each year during that period. Texas alone averages 124 tornadoes a year, which is more than double the average of any other state.

Technology advancements in the second half of the century have contributed to better, more accurate severe weather watches and warnings from the National Weather Service, ultimately saving countless lives.

The biggest advancement for severe weather forecasting was the development of the Doppler radar. Scientists and other researchers took the airborne radar development by the U.S. Military during World War II and applied it to weather forecasting and severe storm identification. The ultimate result was the next generation of radar Doppler that we currently use today.

Advancements in computer technology also made some progress in the area of weather prediction, allowing meteorologists to apply physics in replicating motions of the atmosphere. This, combined with diligent analysis to recognize weather patterns, helped advance severe weather prediction to its current level of an average lead time of over 11 minutes.

Even as we build on our current weather prediction successes and create new resources for predicting windstorms at a greater rate, the United States continues to sustain several billion dollars each year in property and economic losses due to windstorms and human costs are—well, human costs are also very painful. West Texas is particularly vulnerable to the high winds in tornadoes.

A variety of windstorm hazard mitigation measures exist and many more are undergoing research and development. For example, in the past five years the Texas Tech Wind Engineering Research Center has received funding under a cooperative grant with the National Institute for Standards and Technology to research the detrimental effects of windstorms on buildings and to reduce losses from windstorm events. Their work has led to many accomplishments on the national scope. This year they have received an additional $994,000 to carry on their research to improve the economy of shelters and wind resistant construction.

Improving the wind resistance of buildings will only be achieved when there is demand for wind resistant construction by homeowners. The tornado in Lubbock that was so destructive more than 30 years ago is a reminder of how vulnerable we are and how serious we should be about severe weather safety and preparedness.

For the next couple of hours we will hear from expert witnesses, who I will probably introduce in a few minutes, on how current windstorm hazard mitigation works and we will discuss how the Federal Government can help facilitate further research. I look forward to hearing everyone's testimony and I am proud to bring this hearing to the 19th District.

Now I would like to recognize my colleague on the House Science Committee, Congressman Dennis Moore from Kansas, so that he may make some opening remarks. Congressman Moore has been a leader on this issue and currently serves as co-chair of the Wind Hazard Reduction Caucus, an organization which focuses on increasing the awareness of the Members of Congress about the public safety and economic loss issues associated with wind. I would like to thank him and welcome him to Lubbock for this hearing and look forward to working with him on this very important issue. Mr. Moore.

[The prepared statement of Mr. Neugebauer follows:]

PREPARED STATEMENT OF REPRESENTATIVE RANDY NEUGEBAUER

I want to welcome everyone to this hearing where we'll examine the status of windstorm hazard mitigation in the United States and consider the role of federal research and development in windstorm hazard reduction.

On May 11, 1970 tragedy struck Lubbock, Texas. An F5 tornado ripped through downtown Lubbock. Twenty-six people were killed and at least 500 more were injured. The tornado had winds estimated in excess of 200 mph, and damaged or destroyed a large section of the city, mainly north and east of 19th Street and University Avenue—where we sit today.

In the few moments between 9:35 p.m. and the time the funnel lifted into the clouds, the tornado devastated the community along an 8½ mile path. It wrought havoc along a track that was 1½ miles wide in downtown Lubbock to one-fourth mile wide as it passed over the Weather Bureau Office located at the Lubbock Airport. The twister was responsible for 125 million dollars in damage with an estimated 15 square miles of the city damaged or destroyed.

The National Weather Service estimates that between 1995 and 2002, hurricanes, tornadoes, and thunderstorm winds caused an average of 4.5 billion dollars in damage every year. Texas alone averages 124 tornadoes a year, which is more than double the average of any other state.

Technological advancements in the second half of the century have contributed to better, more accurate severe weather watches and warnings from the National Weather Service, ultimately saving countless lives. The biggest advancement for severe weather forecasting was the development of Doppler radar. Scientists and other researchers took the airborne radar developed by the U.S. military during World War II and applied it to weather forecasting and severe storm identification. The ultimate result was the Next Generation Radar Doppler that we currently use.

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Improving the wind resistance of buildings will only be achieved when there is a demand for wind-resistant construction by homeowners. The tornado in Lubbock that was so destructive more than 30 years ago is a reminder of how vulnerable we are and how serious we should be about severe weather safety and preparedness. For the next couple of hours we will hear from expert witnesses, who I will properly introduce in a few minutes, on how the current windstorm hazard mitigation process works and we will discuss how the Federal Government can help facilitate further research. I look forward to hearing everyone's testimony and I'm proud to bring this hearing to the 19th District.

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Mr. MOORE. Thank you very, very much, Congressman Neugebauer, for inviting me here today. I really appreciate your coming up with the idea for this hearing today here in Lubbock and for hosting and basically chairing this committee. I am looking forward to the testimony of our panel of experts here today.

I also want to thank Texas Tech for working with me for the past three Congresses. I have been in Congress now, I'm starting my sixth year. Texas Tech has worked closely with us and my staff in the three Congresses on legislation on this topic. To keep this truly bi-partisan I will also recognize and thank Representative Stenholm for helping to give an initial earmark that brought $3.8 million to the Texas Tech Wind Disaster Research Program in 1998, but I think we owe a special debt of gratitude again to the Congressman here for bringing us here today for this very, very important hearing.

Five months after I took office in 1999, my hometown of Wichita, Kansas, was hit by an F–4 tornado which plowed through the suburb of Hayesville, Kansas, killing six, injuring 150, and causing over $140 million in property damage. The devastation of this attack motivated me to do something about the old Mark Twain adage, "Let's do something about the weather." I put together legislation modeled after NEHRP [National Earthquake Hazards Reduction Program], the successful earthquake research program begun over 30 years ago. My legislation's goal is to mitigate loss of life and property due to wind and related hazards and I am proud to say that the Congressman here is a co-sponsor of this legislation, which I think is very important.

I utilized comments from the American Society of Civil Engineers, the American Association of Homebuilders, the insurance industry, meteorologists, emergency managers, academia, industry, and the Manufactured Housing Association to try to fine tune our legislation and on May 4 of 2003, almost four years to the day after the deadly 1999 Kansas and Oklahoma tornadoes, tornadoes again touched down in metro Kansas City and the surrounding suburbs, which is my district, as well as in many of Science Committee colleagues' Districts, destroying property, killing and injuring our constituents.

These tornadoes didn't check before they hit to see whether they were Republicans or Democrats. Frankly, partisan politics has no place in the discussion here and I think it is very, very important and encouraging, and I think hopeful people in this country are waiting to see us find an issue where we can work truly together on a bi-partisan, non-partisan basis and do the right thing for the people in this country. It's not a Republican issue. It's not a Democratic issue. It's a human issue and it's a human tragedy when a storm like this strikes and destroys property and takes peoples' lives. I have seen it in my district.

I know you have seen it here. I know Lubbock, Texas, was hurt very, very badly several years ago as the Congressman said.

I want to again thank you, Randy, for having this important hearing. I'd also like to thank the witnesses for sharing their expertise here today and we look forward to your testimony and asking you some questions. Thank you very much.

[The prepared statement of Mr. Moore follows:]

Prepared Statement of Representative Dennis Moore

I would like to thank Representative Randy Neugebauer for inviting me here today to Texas Tech and for working with me for the past three Congresses on legislation on this topic and Representative Charlie Stenholm for getting the initial earmark that brought $3.8 million to the Texas Tech's wind disaster research program in 1998.

Five months after I took office in 1999, my hometown of Wichita, Kansas, was attacked by a F4 tornado, which plowed through the suburb of Haysville killing six, injuring 150, and causing over 140 million dollars in damage. The devastation of this attack motivated me to do something "about the weather" to paraphrase the old Mark Twain adage.

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I utilized comments from the American Society of Civil Engineers, the American Association of Home Builders, the insurance industry, meteorologists, emergency managers, academia, industry, and the manufactured housing associations to fine-tune the legislation.

On May 4, 2003, almost four years to the day after the deadly 1999 Kansas and Oklahoma tornadoes, tornadoes touched down in metro Kansas City and the surrounding suburbs as well as in many of my Science Committee colleagues' districts, destroying property, killing and injuring our constituents.

These tornadoes did not check with Congress to see if they were hitting Republican or Democratic districts, just hit both. This is not a Republican or a Democratic issue, it is a human issue—it is a human tragedy. These windstorms destroy lives; I have seen it in my own district and know many of my colleagues have seen it in theirs.

Thank you again, Rep. Neugebauer, for having this important hearing and I would also like to thank the witnesses for sharing their expertise on this extremely important issue.

Mr. NEUGEBAUER. Thank you. I am going to just briefly introduce the panel members to you today. From my left and going right, Dr. Ernst Kiesling, who is Professor of Civil Engineering at Texas Tech University. Dr. Kiesling has 37 years of teaching, research, and administrative experience at Texas Tech University, including serving as Chair of the Civil Engineering Department from 1969 to 1988. Dr. Kiesling was the first to develop an in-residence tornado shelter, providing occupant protection during tornadic events. The research provided the basis for the Federal Emergency Management Agency's qualification on in-residence shelter design.

Next we have Dr. Charles Meade. He is a senior physical scientist with the RAND Corporation of Science and Technology Policy Institute in Washington, D.C. He is the primary author of "Assessing Federal Research Development for Hazard Loss Reduction," a piece prepared for the White House Office of Science and Technology Policy in 2003.

And then Dr. Bo Bienkiewicz. He is a Professor of Civil Engineering at Colorado State University Wind Engineering and Fluids Laboratory. Dr. Bienkiewicz is also the Vice-President of the American Association of Wind Engineering, Secretary of the American Society of Civil Engineering Committee on Wind Effects, and Co-Chairman of the International Wind Engineering Forum.

And finally Dr., I mean Mr. Bryan Shofner. He is President of Shofner & Associates Insurance Agency in Lubbock, Texas. Mr. Shofner was named Young Agent of the Year in 2001 by the Independent Insurance Agents of Texas.

Mr. Shofner is also a long-time member of his local, state, and national independent insurance agent associations, including serving as President of the Lubbock Association of Insurance Agents.

As you know, the format is to give your opening testimony. We are not going to be real strict on the five minutes, but we would like to make those as brief as possible. Your full opening statement will be entered into the record. And then we would then open up for time for question and answer. Dr. Kiesling.

STATEMENT OF DR. ERNST W. KIESLING, PROFESSOR OF CIVIL ENGINEERING, TEXAS TECH UNIVERSITY.

Mr. KIESLING. Thank you for being here today and for your purpose in being here. I am privileged to be the spokesperson for the Wind Science and Engineering Research Program at Texas Tech. I am particularly honored to be standing in for Dr. Kishor Mehta, the long-time Director of the Center, who at this moment is in Asia delivering papers at an international wind conference. Otherwise, he would have been here.

We have engaged in hazard mitigation activities since 1970 when the tornado that Congressman Neugebauer mentioned came to Lubbock, Texas. Improving buildings for wind resistance has been a major focus of our program throughout its history. Damage to buildings, especially houses, comprises a major segment of wind damage so much of my testimony will relate to that segment of the broad field of wind engineering, wind mitigation research.

Our research in hazard mitigation has two major objectives—saving lives and reducing economic losses. The reports and testimonies of other presenters at the table will define the nature and magnitude of our growing vulnerability and discuss the status of research and development efforts.

I will simply give a snapshot of the one productive hazard mitigation program I am familiar with and list some of the opportunities for further reducing our vulnerability.

The collaborative efforts of a number of universities, most notably Colorado State University with its NSF project, have made progress in a number of areas important to curbing the spiraling economic losses to windstorms. I think our major progress in hazard mitigation has been in damage documentation. We have documented the damage in over 130 major storms now in this country and in Australia.

Storm shelters, most commonly known as safe rooms, have gone from an inspiration to a concept, to utilization, to the establishment of an industry. We have come a long way in understanding wind characteristics through laboratory, full-scale tests, and field studies, as well as through observations. We have studied wind effects on buildings in the laboratory and simulations using, for example, a C–130 aircraft. We have made observations in the field on the effects of winds. This played heavily in standards and code development, the ASCE 7, and we are currently involved with the International Code Counsel in developing a national consensus standard for storm shelters. We have been involved in technology transfer through publications, short courses, outreach, and heavily involved in education and inter-disciplinary education at the graduate level to produce graduates who understand the hazards and have potential solutions for meeting those challenges of the hazards.

Yet some of these same areas represent the most fertile ones for the future. We do not have a very good understanding of fluctuating wind blows, particularly in tornadoes and perhaps not even in hurricanes. And then we need to simulate those fluctuating wind fields in the laboratory so that we can economically study the effects of those winds.

The knowledge of building resistance to wind loads is not well known. Progressive failures in the buildings when subjected to these fluctuating wind loads leave a lot of challenges for us. We continue to document damage, but we need to develop a consistent database to make those useful in calibrating wind loss damage models, verifying benefit to cost ratio in theories for improvements, developing uniform standards as a basis for building codes, and influencing the attitudes and behaviors of people.

I think the most effective mitigation actions will be taken when building owners perceive that benefits will be derived from investments made in mitigation measures. They must be able to make well-informed decisions by having credible information available to them and the research community bears the responsibility for providing that information.

There are a number of barriers to progress. Obviously, the limited funding, the access to mitigation funding, mitigation activities, is sometimes hindered by the, say, the strict limitations of funding agencies. That needs to be overcome and I think in writing legislation, we can do that.

There are a number of other limitations, but let me get to the bottom line and say that I view our program here as having made considerable progress in producing some important initial results. A synergy has developed among researchers here and among collaborating institutions. With modest funding we have conducted an applications-oriented research and development that has resulted in some improvements in making buildings more resistant to extreme winds. We believe the benefit to cost ratio is large for the investments made, but the significance of this program is not in the results obtained today, rather these results create a platform from which to launch further research and the program serves as an example of what can be accomplished through focused, sustained research and development efforts.

The seemingly daunting challenges cannot be addressed effectively by a single institution or agency. To be effective in curbing spiraling wind damage losses we must have a coalition of diverse agencies and disciplines pursuing comprehensive, coordinated, multidisciplinary research and development that is focused on the wind hazard and coupled to the implementation strategies.

With such a focused effort, supported by adequate levels of sustained funding, we can expand the synergy of this small program to the national level and include multiple institutions and agencies to effectively pursue the goal of curbing economic losses from extreme winds. The American people will be the beneficiaries of investments we make now. We are confident that the payoff will be significant with benefits to cost ratios uncommonly high for research efforts and I would simply say in closing that we really appreciate your support in the past and for considering the hazard mitigation effort in the future. Thank you.

[The prepared statement of Mr. Kiesling follows:]

PREPARED STATEMENT OF ERNST W. KIESLING

The Potential of Research

The common interest that brings us together is curbing the spiraling losses inflicted upon our country by windstorms. My presentation and report focus largely on one applied research program at Texas Tech University that has proven effective. This program has produced results that are being used by facilities designers to provide occupant protection and to mitigate the effects of windstorms. The model's importance lies not in what has been accomplished—albeit significant as a pioneering effort—but rather to reveal what might be achieved when this model is expanded from a synergistic labor of a few researchers to a focused, coordinated effort among many diverse teams working toward a common goal at several of our leading research and implementation institutions.

Losses

The death, destruction, and disruptions associated with windstorms are felt by all. And while consistent databases on damage and economic impacts are lacking, we can draw conclusions about the increasing devastation and waste of the windstorm hazard. For example, of the ten most costly catastrophes in the U.S., eight are weather-related. In the past 25 years, the U.S. has experienced 57 weather-related disasters in which damages exceeded $1 billion. The total normalized losses from these events totals over $355 billion.

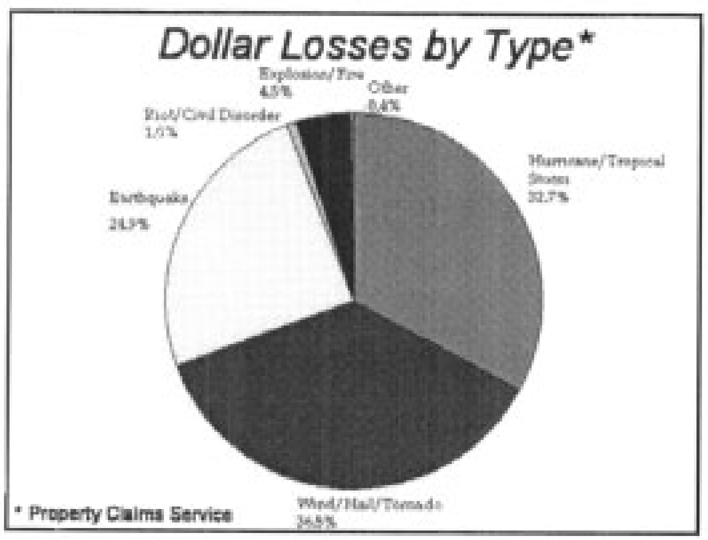
Most Costly Catastrophes

(Adjusted to 2002 dollars)

Aug.	1992	Hurricane Andrew	$19.9 billion
Jan.	1994	Northridge Quake	$15.2 billion
Sep.	1989	Hurricane Hugo	$6.1 billion
Sep.	1998	Hurricane Georges	$3.3 billion
Sep.	1965	Hurricane Betsy	$2.9 billion
Jun.	2001	Tropical Storm Allison	$2.5 billion
Oct.	1995	Hurricane Opal	$2.5 billion
Mar.	1993	Winter Storms	$2.2 billion
Oct.	1991	Oakland, Ca. Fire	$2.2 billion
Apr.	2001	Tornado storm	$2.2 billion

Windstorms are prominent among natural hazards, accounting for about two-thirds of the total losses. The percent of insured losses shown in the pie chart are for the ten year period of 1985–95. Figures in this form are not available beyond 1995.

Population growth, urbanization, and increased property values in harm's way will push future economic losses even higher. We can curb these losses through large-scale, coordinated, multi-disciplinary research connected to effective implementation strategies. Such programs will, over time, have large benefit-to-cost ratios.



Past investments in research and technology have produced improved prediction and warning systems, reducing death and injuries resulting from windstorms. Better warnings have facilitated evacuations from hurricanes, moving people out of harm's way. But population growth has made evacuation less viable in some regions, forcing an alternative strategy—sheltering in place. This is a good strategy for alleviating problems associated with evacuation, but will prove effective only if a sufficient number of shelter spaces are available. Shelter deficits are large in some areas. Without protective shelters that can withstand extreme winds and windborne debris, large-scale casualties are likely, reversing the decreasing death rate of recent decades. Much research is needed toward economical and safe shelter design and cost-effective mitigation of property losses.

National Research Needs

Recent reports by various agencies help define the research needed to abate the windstorm hazard. Over the years, the National Research Council has published a number of useful reports that define the wind hazard and point to needed research. Most recently the RAND report, presented at this hearing by Charles Meade, clearly illuminates needed research and some challenges in implementation. The report of the American Association for Wind Engineering, prepared and presented by Dr. Bogusz Bienkiewicz, yields data emphasizing the importance of mitigation efforts and presents details of a proposed national program for mitigating the effects of windstorms.

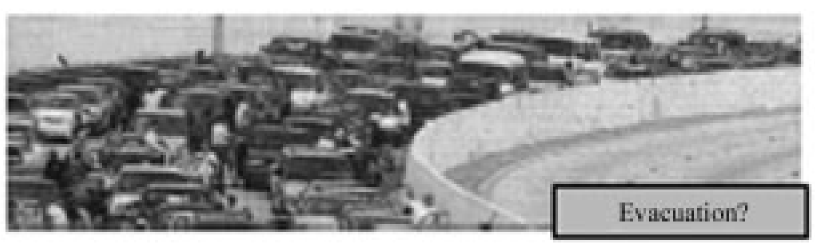
This report, presented by Texas Tech University, deals primarily with progress made in some research areas along with challenges and future opportunities for further research in those areas, and it shows some facilities that are available for continued use by the research community. Technology transfer and education is a significant component of the ongoing effort at Texas Tech University.

Windstorm Hazard Mitigation at Texas Tech: An Overview

Windstorm hazard mitigation research and development started at Texas Tech University on May 11, 1970 when a severe tornado affected half the constructed facilities of the city of Lubbock, killing 26 people and injuring more than 500. A team of researchers from the Civil Engineering Department at Texas Tech joined forces with a special committee of the National Research Council in documenting damage and destruction of buildings by wind forces of the tornado. Since 1970, university personnel have documented and archived damage photographs and other data in more than 130 windstorm events.

The Institute for Disaster Research (IDR) organized and coordinated early programs in windstorm hazard mitigation at Texas Tech. In the 1970s, the Institute pursued research in the destructive nature of tornado and hurricane winds on buildings, enabling them to provide information to:

- The National Weather Service—opening windows in tornadoes does not help
- The Nuclear Regulatory Commission—credible size of windborne debris
- The public—safest places in houses are in a small central room
- School officials—inside hallways are the best areas to seek refuge; avoid large span gymnasiums.

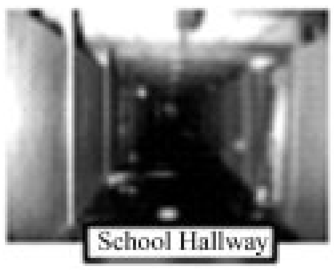


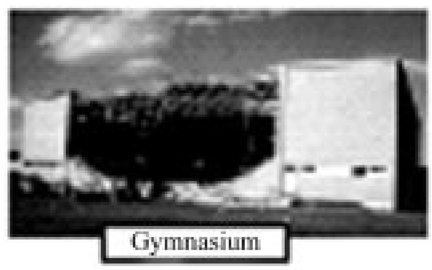
Under the sponsorship of the National Science Foundation (NSF), Defense Civil Preparedness Agency (currently FEMA), National Severe Storms Laboratory (NSSL) and the State of Texas, the Institute published papers, reports, and guidelines for occupant protection and engineering perspectives of tornadic storms.

In the 1980s, with the change of our name to the Wind Engineering Research Center, personnel of the center continued research in wind effects on buildings and the implications of damage. Significant items of technology transfer included the upgrading of wind load standards (chaired the ANSI A 58.1 and ASCE 7 Wind Load Committees), defining consequences of window glass breakage due to windborne debris, and assessing high roof corner pressures obtained in field experiments.

The research program expanded in the 1990s to include meteorology and damage economics; the Center changed its name to Wind Science and Engineering (WISE) Research Center in order to reflect the multidisciplinary approach into which it had evolved. One of the significant research pursuits was the ten-year Cooperative Research in Wind Engineering between Colorado State University and Texas Tech University, which was funded by the National Science Foundation (NSF). This research effort was multidisciplinary and involved fifteen faculty members from the two institutions. The cooperative basic research permitted expansion of research in ground-level wind characteristics, wind damage economics, and wind tunnel and field studies for low-rise building loads. Technology transfer was accomplished for shelter design, leading to prescriptive designs for residential shelters, published by the Federal Emergency Management Agency (FEMA). Implementation of storm shelter (Safe Room) research resulted in the birth of the storm shelter industry and the formation of the National Storm Shelter Association (NSSA) who foster quality in the shelter industry. The Cooperative program also produced building damage prediction models through development of an expert system, established the Information Outreach Center, and graduated students well-versed in windstorm damage and mitigation.

Multidisciplinary research in the WISE Center continues under the sponsorship of the National Institute of Standards and Technology (NIST) and other agencies and private organizations. Currently, faculty members in engineering, atmospheric science, economics, mathematics, and architecture are involved in wind-related research. The facilities of debris impact testing, field site (with a 200-meter tower) at Reese Technology Center, West Texas Mesonet, portable meteorological towers including the SMART radar, and a wind tunnel, permit us to continue our pursuit of research in wind effects on buildings and structures, windstorm damage economics, wind characteristics in hurricanes and tornadoes, the economical design of shelters, soil erosion, and wind energy.





Over the past three decades, WISE Center personnel have pursued collaborative wind research projects with agencies, organizations, and universities, including NIST, the National Science Foundation (NSF), the Federal Emergency Management Administration (FEMA), the National Oceanic and Atmosphere Agency (NOAA), Texas Department of Insurance, Colorado State University, University of Western Ontario, Johns Hopkins University, Clemson University, University of Florida, Texas A&M–Kingsville, and the University of Oklahoma. In the following, a synopsis of research areas of damage documentation, storm shelters, wind effects, standards and codes, wind characteristics, and technology transfer/education are given. The synopsis gives a brief description of the research followed by bulleted items of accomplishments and challenges.

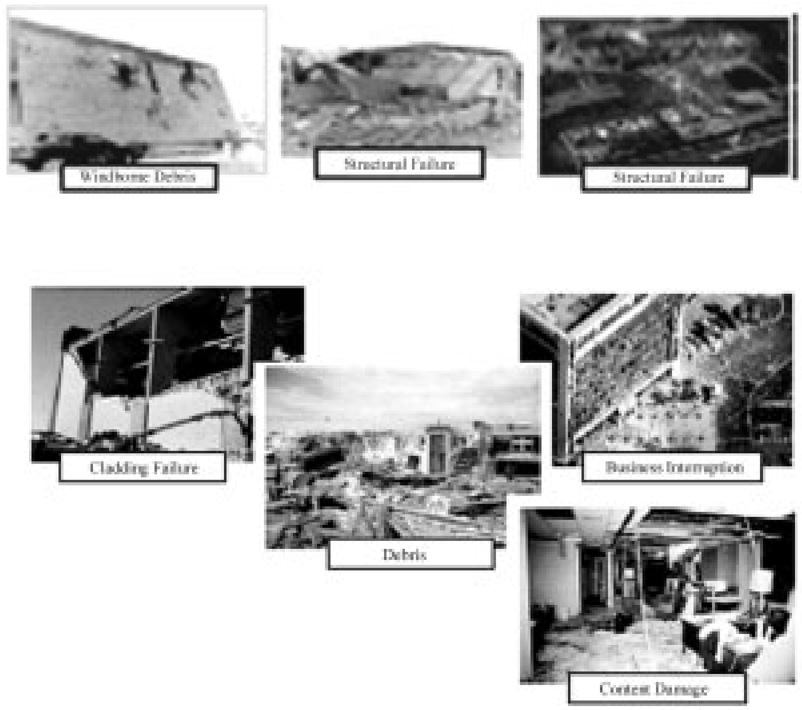
Damage Documentation

Documentation of damage to buildings in Lubbock following the 1970 tornado and the comprehensive report that was published was the first step in Texas Tech's gaining recognition and credibility in damage mitigation research. Damage documentation studies have continued in most of the extreme wind events that have occurred since 1970. Over 130 documentations have been completed, and a large number of photographs and reports have been archived. Information from the archive has been used extensively in seminars, publications, and outreach to the professional design community. The library of the late Dr. Ted Fujita, noted scientist and researcher (originator of F-scale rating for tornadoes) at the University of Chicago, was recently donated to Texas Tech, further enriching this valuable resource.

Lessons Learned

- Central portion of building is the safest
- Opening windows is counterproductive (impacted NWS instructions)

- Low-rise buildings of wood, masonry, light metal fail structurally
- Cladding damage is common
- Debris is abundant in urban areas
- Costly business interruptions are common
- Content damage is extensive



Challenges / Opportunities

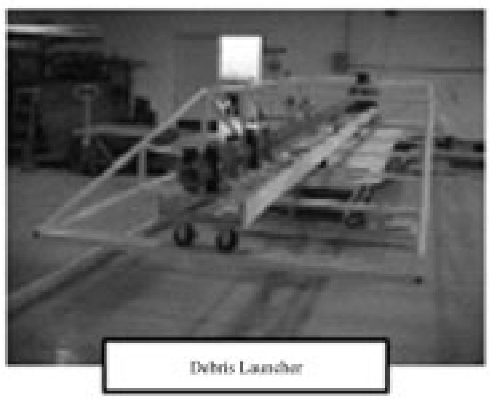
- Collection of statistical data
- Archiving cost data on consistent basis
- Aerial and satellite imagery documentation
- Developing accessible user-friendly data retrieval system

Storm Shelters (Safe Rooms)

Although the concept of the aboveground storm shelter emerged in the 1970s, widespread utilization followed the 1998 publication and distribution of FEMA Publication 320, *Taking Shelter from the Storm—Building a Safe Room Inside Your House.* Soon to follow was FEMA Publication 361, *Design and Construction Guidance for Community Shelters.* Rapid growth of the shelter industry was stimulated by the incentive grant program in Oklahoma following the Oklahoma City tornadoes of 1999. Emerging quality issues in shelter construction led to formation of the National Storm Shelter Association and development of an industry standard (available at www.NSSA.cc). The International Code Council is now developing a national consensus standard for storm shelters. Completion is expected in 2005.


FEMA 320

FEMA 361


Debris Launcher

Accomplishments

- Developed designs with conservative wind loads
- Bridged gap between research and implementation
- Designed and built state-of-the-art debris impact facility
- Provided design input to FEMA 320 and 361 publications

Challenges/Opportunities

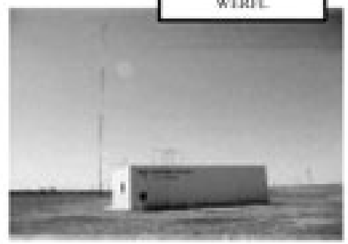
- Optimize site-specific designs for economy
- Foster quality in shelter construction - standards and codes
- Reduce hurricane evacuation with in-home shelters
- Change mindset of public for shelters
- Define incentives to build shelters in existing and new buildings
- Establish programs to fund shelter construction for low income people

Wind Effects

The windy environment in the Lubbock area has permitted us to establish the Wind Engineering Research Field Laboratory (WERFL). A full-size building and a meteorological tower permit measurement of wind pressure data in natural winds. The WERFL facility was an impetus to the pursuit of a cooperative program (funded by NSF) with Colorado State University, which tested the same building in their wind tunnel to improve testing technology.

Innovative testing in the field using a C–130 Hercules aircraft permitted testing of full-size buildings in controlled high winds (gust up to 100 mph). Testing of real buildings to failure in fluctuating winds (not yet tested) will allow us to understand component resistances and progressive failure modes. This understanding leads to credible wind loss models.


CSU Wind Tunnel


WERFL

Accomplishments

- Developed unique WERFL for wind effects
- Measured pressures from natural wind on a building
- Pursued cooperative NSF-funded program with CSU
- Assisted in improving wind tunnel technology
- Tested full-scale building with C–130 prop wash


Wind Tunnel


C-130 Testing

Challenges / Opportunities

- Make WERFL accessible to researchers worldwide
- Develop facility to test full-size buildings to failure
- Build testing facilities for frame and component resistances
- Improve wind tunnel technology for component testing

Standards and Codes

Accredited standards provide a foundation for building codes that establish expectations of quality in the constructed environment. Accurate data is fundamental to establishing reliable standards, forming the basis for codes and ultimately the design of buildings. Consistency of codes, and hence the consolidation of model codes, is important to the design of safe economical buildings. Guidelines based on research permit professionals to design for situations that are beyond codes.

Accomplishments

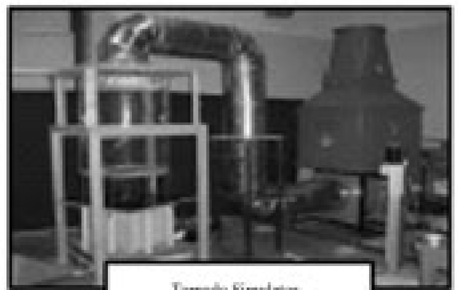
- ASCE 7 Standard is based on physics and scientific data
- One wind load standard is developed for the country
- Model codes are consolidated into one model code
- Statewide building codes are being developed
- ICC/NSSA Standard for storm shelters is being assembled
- Safe areas in school guidelines have been developed

Challenges/Opportunities

- Calibrate prescriptive standards and codes
- Develop performance-based standards
- Develop risk management approach
- Develop cost-benefit models for mitigation measures

Wind Characteristics

Knowledge of near-ground wind field in severe winds (hurricanes, thunderstorms, and tornadoes) and pressures and forces they impart on building components are essential to the design of safe economical buildings. The purpose of this knowledge is to simulate correct wind characteristics in wind tunnels. Current simulations of wind in wind tunnels do not reflect rapidly changing wind speeds in thunderstorms, downdrafts, or tornadoes or, to some extent, in hurricanes. Field measurements of wind in these storms, using stationary and protable towers, provide the necessary input to wind tunnels and, for the future, to computational fluid dynamics technology.



Tornado Simulator

Pulsed Jet Simulator

Accomplishments

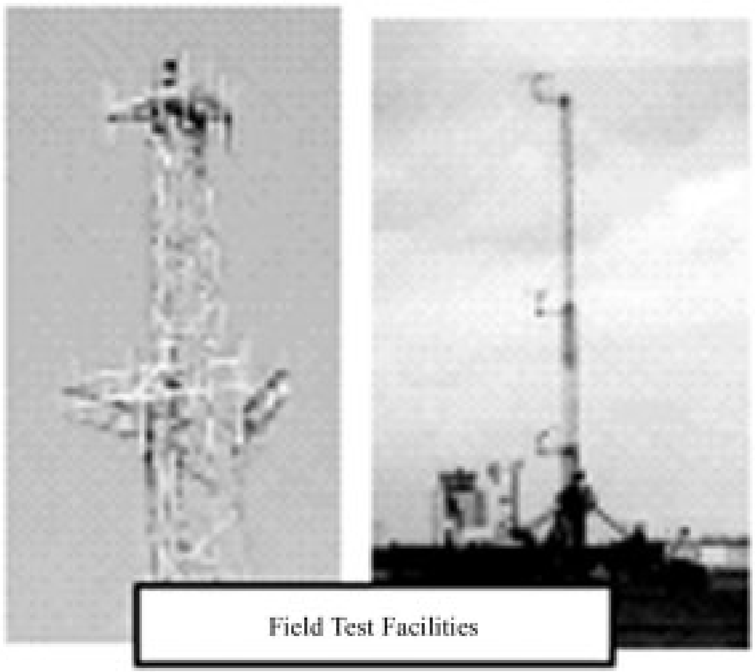
- Measured ground-level wind characteristics in land-falling hurricanes
- Measured time and space correlation of winds in thunderstorms outflow
- Developed (preliminary) laboratory tornado simulator
- Performed initial experiments for downdraft effects on building

Challenges / Opportunities

- Develop credible laboratory model of tornado
- Establish wind characteristic criteria for thunderstorm, tornado, and hurricane storms
- Develop wind tunnel that can simulate rapidly changing winds

Technology Transfer/Education

Research results become useful and valuable when they are implemented to improve the built environment or when they are used to influence human behavior and policy decisions. Information and outreach programs help to transfer technology to professionals and the public at large. We are only beginning to educate college and K-12 students to understand the perils of the wind hazard. The windstorm poses complex problems, and an interdisciplinary approach to approach to develop mitigation strategies and their implementation is needed.



Accomplishments

- ASCE continuing education courses are presented
- Seminars for professionals are presented
- Preview model for HAZUS (FEMA) has been developed
- A limited number of university graduates are being produced

Challenges / Opportunities

- Provide information for public, emergency personnel, and decision makers
- Produce graduates and professionals versed in windstorm disasters
- Complete FEMA/HAZUS model for the wind hazard
- Develop and Implement Interdisciplinary educational program

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BIOGRAPHY FOR ERNST W. KIESLING

Professor of Civil Engineering, Texas Tech University; Executive Director, National Storm Shelter Association

Dr. Kiesling has 40 years of teaching, research, administration and public service in his career at Texas Tech University. He served as Chairman of the Civil Engineering Department for 20 years and as Associate Dean of Engineering for Research for five years. He has been engaged in full-time teaching and research for the past 10 years. He leads the storm shelter research effort within the Wind Science and Engineering Research Center at Texas Tech.

Dr. Kiesling and his colleagues developed the In-Residence storm shelter, an above-ground shelter capable of providing a very high degree of protection from extreme winds. Texas Tech provided shelter designs and other input to FEMA publications on storm shelters.

He was instrumental in founding the National Storm Shelter Association (NSSA), a non-profit trade association dedicated to quality in the shelter industry. He currently serves as Executive Director of the Association.

February 5, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on February 9th for the hearing entitled *Strengthening Windstorm Hazard Mitigation: An Examination of Public and Private Efforts*. In accordance with the Rules Governing Testimony, this letter serves as formal notice of the Federal funding I currently receive in support of my research.

The project entitled *Windstorm Mitigation Initiative* funded by the National Institute for Standards and Technology (Contract Number 70NAB3H5003 with Texas Tech University) has current year funding of $2.6 million. This project is in its sixth year. I serve as Principal Investigator for Task RT - A/D, Building Performance and Shelters, with a fiscal year budget of $358,160.

During the period October - November 2003, I presented three seminars in Kansas for personnel of the U.S. Department of Housing and Urban Development. The subject was construction of storm shelters in low-cost housing. I worked under a contract with ICF Consulting, Contract Number 021228.0.106.07 The total payment was $7,218.69.

Please contact me if additional information is needed. I look forward to the hearing.

Sincerely,

Ernst W. Kiesling

Ernst W. Kiesling, P.E., Ph.D.
Professor

Mr. NEUGEBAUER. Thank you.
Dr. Meade.

STATEMENT OF DR. CHARLES MEADE, SENIOR PHYSICAL SCIENTIST, RAND CORPORATION

Dr. MEADE. Thank you, Mr. Chairman. I am pleased to be here today to discuss the research and findings from the recent RAND report, "Assessing Federal Research and Development for Hazard Loss Reduction." This work, as you note, was carried out at the request of the White House Office of Science and Technology Policy to help formulate a better understanding of the role of our government-sponsored R&D in the Nation's efforts to reduce hazard losses and so it is topical to today's hearing.

Quickly, the principal findings of our studies were considering the entire R&D portfolio that contributes to hazard loss reduction. Explicit hazard loss reduction programs, such as the one you are considering today, are absolutely the smallest component of the federal R&D portfolio. Secondly, the largest fraction of R&D spending supports work on weather hazards and broadly related research on climatology, atmospheric science, and oceanography. And thirdly, much of the R&D spending supports short-term prediction capabilities, specifically largely in the area of weather forecasting.

With this background, my following remarks will address the community's questions for this hearing, starting with number one: Is the United States growing more or less vulnerable to damage from wind hazards and why? The U.S. is growing more vulnerable to wind hazards because of two trends. First, increasing development near the Atlantic and Gulf coast has created large populations and infrastructures that are increasingly vulnerable to hurricane. Data on insured losses from the insurance industry provide a stark measure of this increasing vulnerability. The average annual loss from hurricanes from 1944 to 1988 was $1.1 billion per year. That is insured losses. From 1988 to 1999 this value rose to four times that level, to an average of roughly $4.2 billion per year.

The second component that is increasing the vulnerability is associated with the increasing prevalence of manufactured homes in the central part of the United States, where we are today, which is susceptible to tornadoes.

Because these structures have only minimal wind resistance and no basements, the injury rate is estimated to be 20 times higher than that for conventional homes during high winds.

The most important feature for both of these vulnerabilities is that they could be reduced through appropriate R&D efforts such as you're considering today.

For example, a better understanding of hurricane wind fields after landfall or improved design and engineering of manufactured homes so they are also more resistant to wind hazards.

For the second question you ask: Approximately how much money is the Federal Government going to spend per year on wind hazard mitigation research and development? Answers to this question depend on analysis of two subsidiary questions, both of which were considered in detail in the RAND study. Specifically, what is the definition of government research and development spending and what are the characteristics of R&D for wind hazard mitigation.

On the first issue we utilized RAND's RaDiUS database which details R&D spending across the Federal Government as defined and classified by the OMB. So we used the OMB definition for R&D dollars.

In the second issue we examined all federally-funded R&D applied to natural hazards and they considered contributions explicitly to wind hazard loss reduction. Considering the purposes of this hearing, they differentiated R&D expenditures that support improved engineering designs of structures and those that are focused largely on meteorological applications and weather forecasting. With this framework, R&D expenditures addressed to infrastructure losses were approximately $11 million in FY 2001. By comparison, expenditures for meteorological R&D in weather forecasting were almost 70 times larger, at roughly $755 million.

Considering those loss mitigations, this allegation is problematic because the short-term view of forecasts made only limited contributions to loss reduction. Specifically, forecasts are surely very valuable for evacuations and saving lives, but they do very little to limit the destruction of property in the long-term and larger sense, and losses that occurred during wind hazards.

To address this discrepancy, we restate here and now the policy recommendations that were stated in our RAND report: Number one, there was a need to increase focus. We weigh R&D activities away from short-term prediction efforts and toward the long-term loss reduction goals.

Number two, increase the focus on technologies and information that will reduce infrastructure losses. And three, establish a comprehensive national loss database that can be used as a guidepost for R&D strategies. And four, utilize loss modeling to identify essential R&D topics.

In fact, you may ask, how much damage do wind hazards do in the United States each year? To that we respond, even though wind hazards are detailed in the media and they trigger large government relief efforts, we actually have only a limited understanding of the actual loss levels and how they vary from year to year.

Lack of accurate loss data can be traced to a number of factors. First, most of the data on wind and hazard losses are actually never collected or analyzed. Two, wind losses are driven by the climate, which is extremely variable from year to year. Three, in many cases it is difficult to identify unique wind losses as opposed to say flood losses, which may occur at the same time. Our vulnerability to wind losses is increasing, as I discussed previously. And finally, there are ambiguities in the way that wind and hazard losses are characterized from an economic standpoint. We talked about that at lunch, as I recall.

Considering the above factors, the current understanding of wind losses has been derived from a range of sources with widely varying analytic techniques and they really can only be considered estimates rather than any kind of measurements.

And so with that background and using the data in our own study, we would estimate that the value for wind related losses currently in the United States is on the average of approximately $7 billion per year. But I would emphasize that that's a highly uncertain number and a central recommendation of the RAND study was to emphasize the need to improve the accuracy of these data to provide better guideposts for federal R&D policy related to natural hazards.

With that I close and I appreciate the opportunity to be here today.

[The prepared statement of Dr. Meade follows:]

PREPARED STATEMENT OF CHARLES MEADE

Mr. Chairman: I am pleased to be here to day to discuss the research and findings from the recent RAND report "Assessing Federal Research and Development for Hazard Loss Reduction." This work was carried out at the request of the Office of Science and Technology Policy to help formulate a better understanding of the role of government-sponsored R&D in the Nation's efforts to reduce hazard losses. For this task, RAND conducted an analysis of the full range of federal R&D expenditures guided by the following questions:

- What is the distribution of federal R&D funding across various types of hazards?
- What types of research activities are supported by federal funding?
- What criteria determine the allocation of these funds?
- How do these R&D efforts contribute to hazard loss reduction?

With this approach we carried out an analysis to determine whether there are holes or imbalances in the federal R&D portfolio and whether key areas are being overlooked. We used the results of our analysis to develop a policy framework that will help in future attempts to assess the "payoffs" of various kinds of R&D, including which efforts offer the greatest potential for reducing hazard losses. Finally, we considered the larger issues about the demands placed on R&D to "solve" the problem of hazard losses. Ultimately, we offered suggestions for new ways to frame expectations and demands for R&D in addressing the problem of hazard losses.

The RAND study was motivated by the problem of rapidly growing economic losses from natural hazards. While the United States has experienced a decline in the numbers of lives lost due to earthquakes, hurricanes, floods, tornadoes, and droughts, over the past few decades, the associated costs of natural disasters escalated dramatically over the same period. Between 1978 and 1989, the Federal Emergency Management Agency (FEMA) paid out about $7 billion in disaster relief funds. In the next dozen years, however, payouts increased almost fivefold, to over $39 billion.

The primary cause for the rise appears to be growing population in vulnerable areas. Demographic changes, most dramatically, the mass human migration to coastal and other high-risk areas, have made disasters increasingly costly events. At the same time, increasing concentrations of people and property have escalated the complexity of the Nation's infrastructure—public utilities, critical facilities, transportation systems, communications networks, and the built environment. As the density of the infrastructure increases, particularly in urban areas, the potential losses from natural hazards become greater still.

Because of the heavy financial burden imposed by losses across all sectors of the economy, pressure on the Federal Government to act quickly and effectively to "solve" the problem has been growing. With this motivation, the federal strategy to address the hazard loss problem takes many forms, from providing disaster relief to assisting in the regulation of private insurance to encouraging mitigation efforts through various incentives. A key weapon in the Federal Government's arsenal is its support of research and development (R&D). Specifically, it funds work carried out by the research community to improve understanding of, preparation for, and response to hazards and their impacts.

To answer the questions posed by OSTP, we needed a clear view of hazard loss reduction efforts in the federal R&D portfolio. We therefore conducted an analysis of the federal R&D portfolio for a particular year, FY 2001. Our objective was to identify R&D expenditures that support the goals of reducing losses from natural hazards such as floods, hurricanes, earthquakes, and wildfires. Because the federal budget does not have a separate R&D budget, much less one focused solely on hazard loss, we had to develop a set of detailed criteria to identify hazard loss R&D activities within larger research programs across the Federal Government.

Our data sources were RAND's RaDiUS database and other sources of federal budget information. (RaDiUS stands for research and development in the United States and it includes all federally funded R&D expenditures.) The RaDiUS database details all federal R&D funding as determined by computer records from the Office of Management and Budget (OMB). We also looked at individual agency budget requests, as well as annual R&D reports generated by the Office of the Federal Coordinator for Meteorology, which encompasses the broad range of weather-related federal programs.

Using these sources, we were able to analyze funding from a number of perspectives, quantifying expenditures by agency, hazard type, and program goals. Our key findings were as follows:

- *Explicit hazard loss reduction programs receive the least funding.* Programs dedicated solely to hazard loss reduction R&D receive the smallest share of R&D funds. The largest fraction goes to basic and applied research programs at the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration (NASA). The second largest category is operational support R&D, focused almost exclusively on weather-related hazards.
- *The largest fraction of R&D spending supports work on weather hazards and broadly related research on climatology, atmospheric science, and oceanography.* The second largest category of R&D funding—a distant second—is research on earthquakes. While losses from weather-related hazards are estimated to be approximately twice as large as those from earthquakes, the allocation of R&D funds between these categories differs by more than a factor of 10.
- *Much of the R&D spending supports short-term prediction capabilities.* Closer examination of the funding for weather-related hazard R&D shows that most of the effort is focused on short-term prediction efforts, which have limited loss reduction potential within the full range of losses from natural hazards. Prediction can generally move individuals out of harm's way, but R&D focused on long-term loss reduction strategies could improve the resilience of communities and infrastructure, protecting lives and property in a far more substantial way.

This emphasis on weather-related hazards and prediction means that other areas of hazard R&D receive comparatively less attention. However, decisionmaking in this policy environment is difficult. Despite its investments in hazard loss reduction R&D, the government has yet to establish the essential framework that would enable these efforts to operate efficiently and show their own merit. Developing a more thoughtful strategy for funding allocation depends on the ability to accurately determine the losses resulting from hazards and the losses prevented or reduced by R&D efforts. In turn, it also depends on the willingness of individuals and communities to implement measures designed to reduce hazard losses. In other words, decisionmakers face both quantitative and qualitative challenges in seeking to strengthen the effectiveness of federal hazard loss R&D efforts.

First and foremost among these challenges is the lack of detailed data on losses from natural hazards. (This quantitative gap has been identified and examined in a number of previous policy studies.) Without such data, it is impossible to gauge either the effectiveness of new R&D strategies or their ultimate payoff in terms of losses prevented. Detailed loss data would go a long way toward enabling a more cost-effective distribution of R&D funds.

From a qualitative standpoint, perhaps the most daunting obstacle policymakers face is human nature. Human behavior ultimately controls the scale of disaster losses and thus exerts a major force on R&D policy decisions for hazard loss reduction. While R&D provides useful technical information, its effectiveness is determined by human decisionmaking on issues such as whether to evacuate, where to locate new construction, and whether to implement known mitigation measures in existing communities.

With this background, my following remarks address the Committee's questions for this hearing.

1) Is the United States growing more or less vulnerable to damage from wind hazards, and why? What are some of the top opportunities for, and primary barriers to, reducing these vulnerabilities?

The U.S. has grown more vulnerable to wind hazards because of two trends.

First, increasing development near the Atlantic and Gulf coast has created large populations and infrastructures that are vulnerable to hurricanes. The impact of this development is clearly indicated in the historical trend of insurance payouts for U.S. hurricane losses (see Figure 1). Starting in the early 1980's, the data show increasing losses with time, with an extremely large peak in 1992, associated with Hurricane Andrew. Today, almost all hurricane warnings require huge evacuations with attendant logistical problems and economic losses. In 1999, warnings for Hurricane Floyd resulted in the largest peacetime evacuation in the United States as three million residents along the Atlantic coast moved inland from Florida to North Carolina.

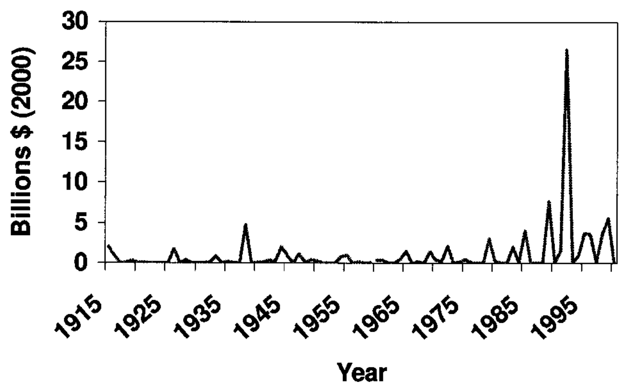

Figure 1 U.S. Hurricane Losses (1915-2000)

Data on insured hurricane losses, from the insurance industry, provide a stark measure of the increasing vulnerability. From 1949 to 1999, catastrophic hurricanes in the United States caused direct insured property losses totaling $37.9 billion—or an average of $743 million per year. To allow comparisons over long time periods, the insurance industry adjusts these values accounting for inflation, population growth, and changes in real tangible wealth. On this basis, the average annual loss from 1944 to 1988 was $1.1 billion. From 1988 to 1999, the values were almost 4 times larger ($4.2 billion). A portion of the increase was driven by the payouts from Hurricane Andrew, which was the largest insured property loss from a natural disaster in U.S. history. Even if one excludes the losses from Andrew, the payouts are almost double the historical trends, suggesting that the increased payouts reflect increasing vulnerability in addition to any fluctuations in hurricane frequency.

The second trend is associated with the prevalence of manufactured housing in the central part of the United States, which is susceptible to tornadoes. Because these structures have only minimal wind resistance, and no basements, the injury rate is extremely high for occupants during high winds. Analyzing historical data, researchers at the National Oceanographic and Atmospheric Administration estimate that the tornado death rate is approximately 20 times higher for residents of manufactured housing compared to conventional structures. In the Midwest, manufactured housing represents approximately 10 percent of current construction.

The most important feature of these vulnerabilities is that they could be reduced through appropriate R&D efforts. For example, better understanding of hurricane wind fields after landfall could be used for improved design and engineering of coastal structures. And experiments and testing of manufactured housing could be used to design more resilient homes.

2) **Approximately how much money does the Federal Government spend per year on wind hazard mitigation research and development? Where is this effort currently focused (i.e., direct vs. indirect research, engineering, economic, meteorological, etc.)? How could the federal wind hazard research and development portfolio be refocused or otherwise strengthened to improve mitigation in the United States?**

Answers to these questions are contingent on the analysis of two subsidiary issues, both of which were considered in detail in the RAND study, *Assessing Federal Research and Development for Hazard Loss Reduction.*

1) What is the definition of government "research and development" spending?
2) What are the characteristics of R&D for "wind hazard mitigation"?

For the first issue, we utilized RAND's RaDiUS database which details R&D spending across the Federal Government, as defined and classified by the Office of Management and Budget. The OMB definition for research and development is "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OMB Circular A–11). Excluded from this category are product testing, quality control, mapping, the collection of general-purpose statistics, experimental production, routine monitoring and evaluation of an operational program, and the training of scientific and technical personnel. This definition, however, is open to the interpretations of numerous individuals at a wide range of government agencies. OMB permits individual agencies a degree of liberty in determining which activities should be considered R&D, allowing each agency to use its own long-standing definition of R&D when reporting such activities to OMB. As a result, the activities that the Department of Interior considers R&D may not be classified as such by the National Science Foundation, whose definition of R&D appears more tightly tied to basic laboratory science.

For the second issue, we examined all federally funded R&D applied to natural hazards, and we considered the contributions to hazard loss reduction. For FY 2001, this analysis found that approximately 90 percent of all R&D funds address weather-related hazards, which includes wind, flooding, extreme temperatures, drought, and large storms. Within this category, most of the funding supports short-term forecasting efforts (e.g., weather prediction, hurricane tracking, etc.).

Considering the goals of loss mitigation, this allocation is problematic because short-term forecasts only make limited contributions to loss reduction. Specifically, forecasts are most useful for evacuations (thereby saving lives), but they do very little to limit the destruction of property. Reducing these losses requires longer-term efforts, involving improved engineering, design, and planning for infrastructure construction.

Considering the purposes of this hearing, we differentiate R&D expenditures that support improved engineering and design of structures from those that are focused largely on meteorological applications and weather forecasting (see table below). Activities in the first category largely include wind engineering research, supported by the National Science Foundation and the National Institute for Standards and Technology. By comparison, the meteorological category encompasses a huge range of basic and applied research on the nature of the global climate system.

Agency R&D Funding for Wind Hazard Mitigation (FY 2001, thousands $)

Infrastructure Losses	
NSF	2,647
NIST	8,387
Subtotal	**11,034**
Meteorological Applications	
NOAA	272,297
NSF	254,594
NASA	198,650
DOT	30,341
Subtotal	**755,882**

With this framework, R&D expenditures addressed to infrastructure losses were $11,034,000 in FY 2001. By comparison, expenditures for meteorological R&D were almost 70 times larger ($755 million).

The difference in funding between infrastructure and meteorological R&D for wind hazards is consistent with one of the principal findings from the RAND study applied to all R&D on natural hazards. Specifically:

- *Much of the R&D spending supports short-term prediction capabilities.* Closer examination of the funding for weather-related hazard R&D shows that most of the effort is focused on short-term prediction efforts, which have limited loss reduction potential within the full range of losses from natural hazards. Prediction can generally move individuals out of harm's way, but R&D focused on long-term loss reduction strategies could improve the resilience of communities and infrastructure, protecting lives and property in a far more substantial way.

  Because the policy recommendations from the RAND study were directed to this problem, we restate them here as a strategic framework for considering new R&D initiatives for wind hazards. Specifically, the government needs to address these issues to ensure that new R&D efforts make a meaningful contribution to loss reduction for wind hazards.

- *Establish a comprehensive national loss database.* Data on hazard losses are central for a host of concerns, including prioritizing R&D efforts, planning budgets for states and localities, developing contingency operations, and conducting cost-benefit analyses for specific measures that will allow policymakers to see the relative value of various R&D efforts and will help citizens to understand the value of implementing long-term mitigation procedures.
- *Utilize loss modeling to identify essential R&D.* Loss modeling, which simulates the impacts of potential disasters, can help determine which hazards generate the greatest avoidable losses, the effects of mitigation steps on loss totals, the time scale for losses, and the budget needs for vulnerable regions to prepare for a prospective hazard. These models hold great promise for prioritizing research needs by weighing the costs and benefits of various mitigation measures against the estimated losses from specific hazards.
- *Re-orient R&D activities toward longer-term loss reduction efforts.* A shift to longer-term, less prediction-oriented efforts holds great potential for reducing losses. The development of technologies to strengthen the built environment can save lives, protect property, and dramatically reduce the costs of rebuilding after a disaster.
- *Increase the focus on technologies and information that will reduce infrastructure losses.* Damage to infrastructure—e.g., buildings, public roads and highways, bridges, water and sewer treatment plants, and emergency services—results in casualties as well as extensive economic losses. The development of improved technologies and information systems can help limit such losses. For instance, greater R&D focus on funding for communications and remote sensing capabilities, geographic information and global positioning systems (GPSs), and modeling and simulation techniques should lead to considerable damage reduction.

3) According to National Weather Service estimates, how much damage do wind hazards cause in the United States each year? How are these numbers compiled?

Each year, the United States suffers significant losses from wind hazards. In the spring, tornadoes wreak havoc in the Midwest. In the summer and fall, hurricanes come ashore, damaging coastal and inland communities. In the case of Isabel in September 2003, this included massive blackouts in cities hundreds of miles from the point of landfall.

Even though these events are detailed in the media, and they trigger large government relief efforts, we have only a limited understanding of the actual loss levels and how they vary with time. In this respect the problem of quantifying wind losses is a component of the larger challenge of quantifying losses from all natural hazards

The lack of accurate loss data and the implications for public policy have been noted in a number of recent studies from the National Academy of Sciences, the Heinz Center for Environment and Public Policy, and RAND. The origin of the problem can be traced to a number of factors:

- **Most of the data on wind and hazard losses are never collected or analyzed.**

  The largest collection of data on wind losses is maintained by the Property Claims Service (PCS), which tracks insurance industry payouts to policyholders following a disaster. While this is a valuable resource for understanding insurance industry losses, it is certainly not a complete picture of wind losses in the United States. Moreover, the database is only available to professionals in the insurance industry. Additional unmeasured components of wind losses occur in the following categories:

Federal: A number of agencies provide disaster relief, but there is no centralized recording of these expenditures.

Private charities: Organizations such as the Red Cross provide vital relief services, using donated and internal resources.

State and municipal governments: These governments incur disaster losses in a number of forms, including relief payouts, overtime for emergency workers, and damage to municipal facilities.

Individuals and private companies: These entities suffer losses which are unmeasured and uncompensated by the above sources.

- **Wind losses are driven by the climate, which is extremely variable from year to year.**

  As a result, the level of wind losses can vary tremendously from year to year. However, the origins of the variability are complex. Part of the problem is driven by inter-annual climate fluctuations, which produce large variations in the number of windstorms. For example, over the past 90 years, the annual number of hurricanes making landfall on the United States has ranged from 8 to 0. By comparison, the annual number of reported tornadoes has ranged from approximately 500 to 1500 over the past 50 years. However, these changes only explain part of the loss variations, because the loss levels are also driven by event magnitudes and locations, which are uncorrelated with the number of storms in a given year. Hurricane Andrew emphasized this problem in 1992. The hurricane resulted in the largest insurance payments for any natural disaster in the United States ($15.5 billion), yet it occurred in a year with only an average number of storms.

- **In many cases, it is difficult to identify unique "wind" losses.**

  Except for tornadoes, most wind hazards are accompanied by large amounts of precipitation (rain, snow, hail), which complicates the process of determining causes of the resulting damage. For example, wind may blow a tree over, but only because rain has softened the ground. Hurricanes are usually accompanied by large amounts of flooding and water damage. And hail may be especially damaging because it hits objects with high wind velocities. Even the detailed Property Claims Service loss database does not distinguish the different origins for these wind-related losses.

- **Our vulnerability to wind hazards is increasing.**

  As a result, trends in wind losses are strongly influenced by societal decisions regarding the design and location for new infrastructure. These issues are discussed in greater in response to Question 1.

- **There are ambiguities in the way that wind and hazard losses are characterized.**

  While losses are usually reported as an aggregate number, it is important to distinguish the types of losses in an economic context. At the top level, the most important distinctions are between "direct" and "indirect" losses. The first category refers to losses that are directly associated with the damage (e.g., a house that is destroyed by a tornado), while the second involves the secondary effects of a disaster (e.g., someone looses his job because the disaster impacted his employer). From a measurement standpoint, the direct losses are much easier to quantify, and they only occur around the time of disaster. In contrast, indirect losses are somewhat subjective, and they are spread out in time, as the impacts of a disaster ripples through the economy. Although they are rarely discussed, benefits offset some of these losses (e.g., economic benefits of rebuilding damaged infrastructure). Considering all of these loss categories, the clearly are challenges to making an accurate and complete measurement of the losses for a particular hazard.

Considering the above factors, the current understanding of wind losses has been derived from a range of sources, with widely varying analytic techniques. As such, the results of this work are presented as estimates, rather than measurements of hazard losses. At this level of detail, the estimates cannot be used to assess the effectiveness of different R&D strategies. However, they do provide a top-level description of the loss magnitudes and the variation among different types of hazards. With this background, the estimated annualized losses for wind related hazards, from a variety of sources, are presented in the following table.

Estimated Annualized Losses For Wind-Related Hazards	
Hazard	Estimated Annualized Loss ($ Billions)
Hurricanes	5.0
Winter storms	0.3
Tornadoes	1.0
Hail	0.7
Total	**7.0**

A central recommendation of the RAND study emphasized the need to improve the accuracy of these data to provide better guideposts for federal R&D policy related to natural hazards.

I appreciate the opportunity to be here today.

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BIOGRAPHY FOR CHARLES MEADE

Charles Meade, Ph.D., is a Senior Scientist with the RAND Corporation. His research focuses on risk management for catastrophic threats such as, natural disasters, terrorism and nuclear proliferation. For the White House Office of Science and Technology Policy, Dr. Meade carried out a comprehensive analysis of R&D focused on natural disasters, and he recently led a terrorism risk reduction study for the largest worldwide banking consortium. In the past 18 months, Dr. Meade's research contributed to the work of the high-level Gilmore Commission, the National Response Plan promulgated by the Secretary of Homeland Security, and the White House review of critical infrastructure protection strategies. Previously, he led a large study for General Shalikashvili on U.S. efforts to reduce threats from nuclear proliferation. He also performed a comprehensive analysis of seismic mitigation strategies for all California hospitals, as mandated by state seismic safety laws. From 1995 to 1997, Dr. Meade served at the National Research Council of the U.S. National Academy of Sciences where he directed policy studies in the Earth Sciences. From 1990–1995, he was a scientist at the Carnegie Institution of Washington where he led a research program in experimental geophysics. Dr. Meade is the author of 42 peer-reviewed research publications, nine policy studies published by the National Academy of Sciences, an edited book on the *Comprehensive Nuclear Test Ban Treaty,* and a syndicated op-ed on warnings for terrorist threats. He received a Ph.D. in Geology (1990) and a B.S. in Political Economy (1983) from the University of California, Berkeley.

Mr. NEUGEBAUER. Thank you, Dr. Meade.

Dr. Bienkiewicz.

STATEMENT OF DR. BOGUSZ BIENKIEWICZ, PROFESSOR, DEPARTMENT OF CIVIL ENGINEERING, COLORADO STATE UNIVERSITY

Dr. BIENKIEWICZ. Thank you, Mr. Chairman. I very much appreciate the opportunity to be in front of this committee. My testimony covers the following topics: First, a brief overview of research carried out at Colorado State University. Second, a brief discussion of windstorm damage in the United States. And third, discussion of a proposal for the establishment of a National Wind Hazards Reduction Program. These topics are addressed in some detail in my written testimony and more details I have provided with the report I have attached with the testimony. I present brief highlights of some of the topics.

First, I will present a brief overview of wind engineering research at Wind Engineering and Fluids Laboratory at Colorado State University. For over 40 years this laboratory has been the center of excellence for fundamental and applied research in wind engineering and fluid dynamics. The core of this laboratory is three large boundary-layer wind tunnels that allow for realistic modeling of atmospheric boundary layer flows. One of the early long-term research programs carried out in our laboratories in the 60's was modeling and assessment of dispersion of chemical agents released from various sources under various atmospheric conditions. Post-9/11 concerns regarding potential intentional release of chemical, biological, or radiological agents in urban, suburban, and rural settings led to renewed interest in any capabilities existing in our laboratory.

A significant number of investigations carried out at our laboratory addressed wind effects on buildings and structures and mitigation measures to minimize these effects. Wind engineering studies included landmark buildings such as World Trade Center, Sears Tower, and support facilities for Space Shuttle Operation Center at Cape Canaveral. Also we looked at other structures, including long-span bridges, roofs, slender towers, stacks and others. In addition, research included environmental assessment of sitings of fossil and nuclear power plants and renewable energy installations. Determination and mitigation of wind effects on low-rise buildings and building components has been the main thrust of R&D carried out at our laboratory in recent years. In 1990 a majority of these activities were carried out within the framework of the Cooperative Program in Wind Engineering involving faculty and students from Texas Tech and from Colorado State University.

Now we turn our attention to the issue of the impact of windstorm hazards in the United States. Hurricanes, tornadoes, thunderstorms, and associated phenomena cause an excessive level of property losses and human suffering in the United States. The average annual financial loss due to this, however, is difficult to state with precision, but it exceeds $6 billion. A single large hurricane could cause losses far in excess of the $25 billion attributed to Hurricane Andrew in 1992.

As the result of public and private efforts a number of wind hazard mitigation measures have been developed over the years and put into practice in coastal areas and in other regions. These measures led to significant reduction in fatalities attributed to wind hazards; however, they did not result in reversing a lot of material and business losses and ultimately, therefore, it is needed to address this issue.

These issues are discussed in more detail in my testimony and in the attached report. Arguments presented by the documents show that a coordinated, comprehensive, and long-term effort would be necessary to achieve significant reduction in property damage due to wind hazards in the U.S. within the next 10 to 20 years. It is proposed that such an effort be undertaken within the framework of a federal program, the Wind Hazards Reduction Program.

The proposed concept of the National Wind Hazards Reduction Program builds on lessons learned from the 25-year experience with the National Earthquake Hazards Reduction Program. The research and outreach plan proposed for this program is an adaptation of the recently revised plan developed for NEHRP.

This program consists of four components. The first component is focused on improved understanding of wind hazards. The second component addresses issues of assessment of impact of wind hazards. The focus of the third component is reduction of impact of wind hazards. The fourth and final component addresses issues of enhanced community resilience, education, and outreach. Efforts specified for each component consist of research and outreach tasks. A detailed list of these tasks is provided in the testimony and more details can be found in the report.

Recent revolutionary developments in information technology have the potential to reach to unprecedented breakthroughs in our effort to reduce property losses and human suffering due to wind hazards.

In closing I would like to offer the following remarks: First, reduction of wind-induced property losses and human suffering will require a well-planned and coordinated comprehensive action. The existing wind engineering and wind hazard mitigation infrastructure and human resources provide a critical must for starter activities of such undertaking. The proposed wind hazards reduction program provides a frame of implementation for wind hazard reduction needed within the United States. Establishment of such a program would require long-term commitment by the Federal Government. And finally, delaying implementation of such a program, and a delay in adjustment in federal support for wind engineering and disciplines related to wind hazard mitigation, will further impair this nation's ability to defuse the devastating impacts of wind hazards. Thank you.

[The prepared statement of Dr. Bienkiewicz follows:]

PREPARED STATEMENT OF BOGUSZ (BO) BIENKIEWICZ

Introduction

I very much appreciate the opportunity to appear before this committee and to testify in this hearing. In this testimony I will first present a brief overview of research activities carried out at the Wind Engineering and Fluids Laboratory at Colorado State University. Next, I will address issues associated with wind damage and damage mitigation in the United States, including a brief assessment of vulnerability to wind hazards and opportunities to reduce these vulnerabilities. Finally I will discuss a potential for strengthening the federal wind hazards research and development in the United States through establishment of the National Wind Hazards Reduction Program. These topics are discussed in more detail in a report entitled "Wind Engineering Research and Outreach Plan to Reduce Losses due to Wind Hazards"[1] prepared by American Association for Wind Engineering in collaboration with American Society of Civil Engineers. *(This report appears in Appendix 1: Additional Material for the Record.)*

[1] "Wind Engineering Research and Outreach Plan to Reduce Losses Due to Wind Hazards," Report by American Association for Wind Engineering, in collaboration with American Society of Civil Engineers, February 2004, 37 pp.

Wind Engineering Research at Wind Engineering and Fluids Laboratory

For over 40 years, the Wind Engineering and Fluids Laboratory (WEFL), formerly the Fluid Dynamics and Diffusion Laboratory *(www.windlab.colostate.edu)* has been the center of excellence for fundamental and applied research in wind engineering and fluid dynamics. It is one of the international laboratories where the foundations of wind engineering were established. The core of WEFL are three large boundary-layer wind tunnels that allow for realistic modeling of the atmospheric boundary layer. This laboratory was originally established to perform fundamental research on the structure of turbulent boundary layer flows and to develop experimental techniques for modeling atmospheric boundary layers under various flow conditions and thermal stratifications. One of the early long-term research programs carried out at WEFL (in 1960-ties) was modeling and assessment of dispersion of chemical agents released from various sources, under varied atmospheric conditions. Post 9/11 concerns regarding potential intentional release of chemical/biological/radiological agent(s) in urban/suburban/rural settings, as addressed in a report recently released by the National Research Council,[2] led to renewed interest by various federal/state and other public entities in the unique physical modeling capabilities existing at WEFL.

Over the years a great variety of studies of flows and their interaction with natural and built environment have been carried out at WEFL. A significant number of investigations addressed wind effects on buildings and structures and mitigation measures to minimize these effects. Wind engineering studies of a number of landmark buildings designed and subsequently built in the United States were carried out at WEFL. They included the New York's World Trade Center Towers, Chicago's Sears Tower and other tall buildings built in the United States. In addition, wind engineering studies were carried out to determine wind loading on and aerodynamic response of other structures (including long-span bridges and roofs, slender towers and stacks) and environmental assessments for sitting of fossil fuel and nuclear power plants as well as evaluation of sitting and performance of renewable energy (solar and wind power) installations. Determination and mitigation of wind effects on low-rise buildings and building components and systems (including innovative roofing systems) have been the main thrust of R&D carried out at WEFL in recent years.

A representative example of an involvement of WEFL in a coordinated effort focused on reducing vulnerability of built environment to wind hazards is participation of WEFL in a Cooperative Program in Wind Engineering (CPWE) involving researchers and students from Colorado State University (CSU) and Texas Tech University (TTU). This 10-year program supported by the National Science Foundation consisted of a number of research tasks that were addressed by collaborative teams comprising of researchers and students (graduate and undergraduate) from the two institutions. The CPWE teams made significant research, education and outreach contributions in the area of better understanding of wind hazards, their impact on low-rise buildings and structures, and mitigation of these hazards. It should be noted that one of the outcomes of the CPWE research is the design wind speed map incorporated in the ASCE 7 Standard.[3] Other major accomplishments of this program included: development of refined physical modeling techniques for wind engineering studies of low-rise buildings and structures, formulation of hybrid (incorporating analytical, numerical and experimental components) models for innovative (permeable, loose-laid) roofing systems, development of numerical simulation and visualization tools, and others. The outcomes of the CPWE effort have been subsequently utilized in applied research and in wind engineering service carried out at WEFL, TTU and at other institutions and private industry. A representative example of transfer of technology advanced through the CPWE at WEFL is application of the developed tools to predict and mitigate undesired wind effects on innovative roofing systems (including systems incorporating photovoltaic solar panels) and other roofing products developed by U.S. roofing manufacturers and solar energy providers. At TTU, various initiatives were undertaken to expand wind hazards research and enhance technology transfer through effective outreach activities.

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[2] "Tracking and Predicting the Atmospheric Dispersion of Hazardous Materials. Implications for Homeland Security," National Research Council Report, ISBN 0–309–08926–3, National Academy Press, Washington, D.C., 2003, 93 pp.

[3] ASCE 7 Standard, "Minimum Design Loads for Buildings and Other Structures," American Society of Civil Engineers, 2002, 330 pp.

Impact of Windstorm Hazards in the United States

Wind-related events inflict major loss of life and material losses in the United States. According to a report published by RAND[4] (RAND Report), the annualized material losses attributed to wind hazards (inclusive of hurricanes, tornadoes and winter storms) are estimated to be $6.3 billion. They exceed by over 40 percent and 60 percent losses attributed respectively to earthquakes and floods. As the authors of the RAND report point out, attempts to provide the hazard loss data (and this applies to any natural hazard) face a number of challenges. They include the variability in occurrence times and magnitude of events resulting in measurable losses, the length of the averaging period used in calculating the annualized losses, and other factors. Calculation of the annualized losses is further complicated by lack of national database of the losses and changing society's vulnerability to wind and other hazards.

The above wind damage statistics are dominated by hurricane events of large magnitude. For example, in 1992 Hurricane Andrew resulted in $26.5 billion—the highest level of direct and indirect economic losses ever sustained in the United States as the result of a natural hazard event. Analysis of material damage due to landfall of hurricanes in the south-eastern United States over the period 1925–1995 showed that the overall damage due to the reported 244 hurricanes and significant tropical storms exceeded $340 billion, with most of the damage attributed to a relatively small number of strong hurricanes—of category 3 and higher on the Saffir-Simpson Scale.[5]

The highest level of property damage and loss of life has been attributed in the United States to hurricanes, tropical storms, tornadoes and thunderstorms. While devastating effects of landfall of hurricanes have been primarily limited to the Atlantic and Gulf coast regions and the United States territories, hazards due to tornadoes and thunderstorms are of concern to inhabitants of most of the Nation. The highest numbers of fatalities and injuries are attributed to tornadoes. Although most of the largest tornadoes occur in the central United States—the tornado alley—tornadoes have been reported both west and east of the alley. Tornado touchdowns in Maryland, Utah and other states are good illustration of a wide territorial reach of destructive tornadoes. Thousands of thunderstorms occur every year all over the United States. Strong winds associated with passage of thunderstorms (at times accompanied by tornadoes, gust fronts and downbursts) result in a significant physical damage and human suffering. Local topographic features may lead to amplification of such winds, thus compounding adverse wind effects. Mountain ranges may lead to generation of local strong winds, such as down slope Chinook wind in Rocky Mountains, Santa Anna wind in California and strong winds in the northwestern U.S. and in Alaska.

Overall (approximate) measure of the potential wind hazard is represented by wind speed maps. Wind provisions of design codes and standards, such as the American Society of Civil Engineers Standard ASCE 7,[3] provide the recommended design wind speed maps. They typically include disclaimers /restrictions to account for uncertainties/lack of reliable wind speed data.

Storm surge and heavy precipitation accompanying hurricanes both contribute to overall damage and have a potential for causing loss of life and various long-term undesired consequences. Precipitation associated with thunderstorms and tornadoes may lead to severe flash flooding. Other undesired effects associated with high-wind events include disruptions in transportation during winter storms (due to whiteouts and/or snowdrifts), summer dust storms and hail storms, and adverse wind effects on fires.

As a result of ongoing public and private efforts a number of wind hazards mitigation measures have been developed and put in practice in coastal and other regions of the United States. These measures have led to significant reduction in fatalities attributed to wind hazards, mainly due to improved warning times and life protection systems (shelters) in tornado prone regions, and improved forecasting of hurricane landfall and more effective evacuation measures in the Atlantic and Gulf coast areas of the United States.

While the available statistics on human losses due to wind hazards show an encouraging trend of reduction of loss of life, the data on the property losses due to wind hazards exhibit an opposite trend—increasing annualized losses—with alarm-

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[4] Meade, C. and Abbott, M., "Assessing Federal Research and Development for Hazard Loss Reduction," RAND Report, 2003, 65 pp.

[5] Willoughby, H.E., "A Century of Progress in Tracking and Warning—Improvements in Observations, Models, and Forecasts," in *Hurricane! Coping with Disaster,* Simpson, R. (Editor), American Geophysical Union, 2003, pp. 205–216.

ingly increasing rate of change in the losses, especially over the past decade. An intensified coordinated effort to reduce these losses is desirable.

Barriers to Reducing Vulnerability to Wind Hazards

In discussion of the material costs of natural disasters, the authors of the RAND Report noted a significant increase (reported by GAO, in 2002) in the disaster relief funds allocated by FEMA: from $7 billion over the period of 1978–89 to $39 billion over the next twelve-year period.

The authors identified a growing (indeed "exploding") population in areas vulnerable to natural hazards (such as coastal areas) as one of primary reasons for such a dramatic increase in damage and the associated relief funds. A significant portion of these funds has been used to offset material losses due to wind hazards. It has been postulated that the above demographic trend will continue and that significant measures need to be urgently undertaken in order to address the issue of the increasing material losses (and associated relief funds) due to wind hazards.

A number of factors impeding mitigation of damage due to wind and other natural hazards have been identified by natural hazards mitigation community comprising of researchers and practitioners of broad background, decision and policy makers, and others. The domain of their evaluation included research and development, technology transfer and implementation, as well as outreach and education. Some of the impediments to effective mitigation of losses due to natural (including wind) hazards were postulated to be coupled with federal funding policies. The authors of the RAND Report concluded that in a number of programs explicit hazard loss reduction activities received the least R&D funding, while much of the spending supported short-term prediction capabilities of limited potential to long-term loss reduction that could improve the resilience of communities and infrastructure, and ultimately result in substantial reduction of losses. A large disparity between federal R&D funding allocated for different natural hazards also was noted.

As was reported before the Committee of Science of the U.S. House of Representatives (testimony by Dr. McCabe,[6] during hearing on October 11, 2001), the average annual overall federal investment in research to mitigate impacts of wind hazards is estimated to be $ 5–10 million. It is instructive to compare this amount with FY 2001 funding allocations for fundamental research by National Science Foundation: Civil & Mechanical Systems—Wind—$2.6 million, Earthquakes—$20.8 million; Atmospheric Sciences: Wind+Flood+Drought—$183.8 million, RAND Report, p. 23. It should be noted that the federal funding in excess of $100 million per annum has been invested over the past two decades to support activities geared towards reduction in earthquake losses, through the National Earthquake Hazards Reduction Program. A comparison of these funding levels with the quoted earlier estimate for the annualized wind hazards losses suggests that a significant increase in federal investment in activities geared towards reduction of losses due to wind hazards is urgently needed, justified, and has considerable potential for short- and long-term payoff.

Wind Engineering/Wind Hazards Research Needs

A list of wind engineering research areas identified as critical for reduction of wind-induced loses is provided in the report published by American Association for Wind Engineering.[7] It included: Collection of wind speed data using robust instrumentation and state-of-the art technology to map detailed structure of the wind, topographic effects, and long-term climate effects; Simulation of hurricanes and their wind fields and other extreme wind effects for statistical analysis of wind, wind loads, and wind-induced response of structures and their components; Modeling of wind-structure interaction, including effects of integral wind loads on structural systems, components and cladding, effectiveness of retrofitting schemes, effects of structural fatigue and impact by wind-generated missiles, design of cost effective tornado shelters and shelters for hurricane zones to minimize evacuation; Study of internal load paths, performance of structural systems, and effectiveness of connections between structural components; Field monitoring of structures in natural environment and large-scale tests in simulated loading environment; Research in debris impact potential in windstorm and development of impact resistant building components; Mapping of wind climate in urban areas; Health monitoring and structural control studies for mitigation of wind effects; Application of effective numerical

[6] McCabe, S.L., Testimony on behalf of American Society of Civil Engineers before the Subcommittee on Environment, Technology and Standards, of the Science Committee, U.S. House of Representatives, October 11, 2001.

[7] "Wind Engineering: New Opportunities to Reduce Wind Hazard Losses and Improve Quality of Life in the USA," American Association for Wind Engineering Report, August 1997, 74 pp.

schemes using computational fluid dynamics to determine the wind environment and wind loading on and response of buildings, structures, transportation systems and other critical components of civil engineering infrastructure, and to mitigate these effects; Development of effective techniques for collection and rapid archiving and dissemination of data acquired during post-disaster investigations; Development of cost-effective retrofit techniques to enhance wind resistance of existing structures; and Development and application of reliable techniques for cost-benefit analysis of wind hazards mitigation measures and other socio-economic evaluations.

Opportunities to Reduce Vulnerability to Wind Hazards

The existing R&D infrastructure and expertise in wind engineering and other disciplines pertinent to mitigation of wind hazards, recent advances in information technology as well as lessons learned from programs focused on mitigation of other natural hazards, especially earthquakes, form the basis that provides unique opportunities to enhance our efforts to reduce vulnerabilities to wind hazards.

The existing research infrastructure includes laboratory and field facilities used to investigate wind characteristics and wind effects on buildings and structures and their components. The main components of the laboratory infrastructure are long-test-section wind tunnels that allow for realistic modeling of boundary-layer winds and other flow modeling facilities that have been employed in exploratory modeling of other wind phenomena, including tornadoes, hurricanes and downburst outflows. Academic institutions in the United States involved in laboratory modeling of wind effects include: Colorado State University, Texas Tech University, Clemson University, Iowa State University, Louisiana State University and University of Notre Dame.

Over the years, extensive wind engineering field studies of wind effects on low-rise buildings and wind hazards mitigation have been carried out by researchers at Texas Tech University, at two sites in Lubbock, TX. A field site to carry out wind engineering investigations primarily focused on manufactured homes was established (and jointly operated by the DOE's Idaho Environmental Engineering Laboratory and University of Wyoming) 30 miles west of Laramie, WY.

Several universities have established programs to collect high fidelity hurricane wind field information near ground, and wind loading on building envelope and building performance during strong wind events. A number of houses at various locations along Atlantic and Gulf coasts have been instrumented or outfitted with wiring and brackets for easy installation of instrumentation. These efforts have been carried out by researchers from Clemson University, University of Florida at Gainesville and University of Illinois at Urbana-Champagn. Several wind engineering research groups (Texas Tech University, Clemson University and University of Florida at Gainesville) use mobile towers (typically 30 feet in height) strategically positioned on an expected path of hurricanes or other high-wind events. These instrumented towers are equipped with back-up power supply and they are capable of withstanding wind speeds up to 200 mph. Recent upgrades of the towers included use of wireless phone communication (successfully deployed for the first time during landfall of Hurricane Isabel in 2003) to transmit the acquired data to a central database in near-real time.

Another example of an innovative application of the emerging sensors, data acquisition and transmission technology is a recent study coordinated by researchers from University of Notre Dame who have been supplementing traditional monitoring devices in measurement of wind-induced response of tall buildings using the Global Positioning System (GPS).

The above cases are only a representative sample of applications of new technologies incoroporated in current R&D focused on mitigation of wind hazards. The revolutionary role of information technology (IT) and unmatched opportunities resulting from its application in efforts geared to reduce vulnerability to natural disasters were discussed in RAND Report. Specific applications of IT in monitoring and simulating seismic hazards and structural response due to earthquakes, as well as in remote data acquisition and interpretation coupled with rapid communication and visualization to aid broad range of stakeholders (ranging from R&D through decision-making and emergency personnel) were discussed in EERI Report.[8] The described applications (of IT) appear to have a tremendous potential to aid tasks to reduce vulnerability to wind hazards and to coordinate local and regional planning to prevent/minimize wind-induced losses.

[8] "Securing Society Against Catastrophic Earthquake Losses—A Research and Outreach Plan in Earthquake Engineering," Earthquake Engineering Research Institute Report, April 2003, 62 pp.

Benefits of Coordinated Wind Hazards Mitigation Research

Reducing wind hazards risk is a long-term commitment that builds on past experience and advances in our understanding of wind, wind-induced loading on and response of structures, impact of wind-generated debris, and effects of other natural phenomena associated with strong winds (for example surge, hail). Advances in quantifying the physical nature of strong winds, coupled with continuing improvements in engineering methods, will result in significantly increased wind hazard safety, as structures existing in critical wind zones are retrofitted, and new and replacement structures and infrastructure systems are constructed. Research on wind hazards can significantly reduce economic losses resulting from future strong-wind events. Whereas several success stories can be cited, there is a pressing need to continue such research in the future, and at an increased rate.

Because our nation's livelihood is highly dependent on business activity, a future wind event, even one with only a moderate damage potential, can result in significant economic loss. In an extreme case, the recurrence of a hurricane with the magnitude of hurricane Andrew, with landfall passage over a metropolitan area (such as Miami, Florida) would be devastating. Total loss associated with such event is estimated to exceed $30 billion, with a significant portion of this loss attributable to interruptions in business operations. The tragic events of 9/11 in New York City underscore the severity of economic impact of a major disruption in urban infrastructure and interruptions in business activities.

If relevant and timely research coupled with effective technology transfer can reduce the economic loss from a single future strong wind event by even a very conservative 10 percent, the payoff on the investment will be in the billions of dollars.

Proposal for Establishment of National Wind Hazards Reduction Program (NWHRP)

In context of arguments put forth in this presentation and findings advanced elsewhere (AAWE Reports,[1,7] RAND Report,[4] NRC Report,[9] NIST Report[10]), and in view of the current and anticipated future unacceptably high level of wind damage it should be apparent that effective countermeasures are urgently needed and can be developed to stem and reverse these undesirable trends. Evidence has been also presented to support a proposition that an integrated and coordinated long-term effort with well defined, achievable and measurable goals in R&D, education and outreach will be necessary to significantly reduce societal vulnerability to wind hazards with 10–20 year time horizon. Such a goal could be accomplished through establishment of the National Wind Hazards Reduction Program (NWHRP). The establishment of such a program was proposed in the past by Jones et al.[11] and others (NRC Report,[9] NIST Report[10]).

The concept and implementation of NWHRP program could be built on lessons learned from the 25-year experience with the National Earthquake Hazards Reduction Program (NEHRP). The starting point in this process could be the revised concept of the NEHRP described in the EERI Report.[8] Adaptation of this model for the NWHRP is presented in the AAWE Report.[1] The main components of the program are summarized in Table 1, while the research and outreach tasks are listed in Table 2.

[9] "Wind and the Built Environment—U.S. Needs in Wind Engineering and Hazard Mitigation," National Research Council Report, ISBN 0–309–04449–9, National Academy Press, Washington, D.C., 1993, 130 pp.

[10] Marshall, R.D., Editor, "Proceedings of Workshop on Research Needs in Wind Engineering," Technical Report NISTIR 5597, Building and Fire Research Laboratory, National Institute of Standards and Technology, Gaithersburg, MD, 1995, 69 pp.

[11] Jones, N.P., Reed, D.A., and Cermak, J.E., "Wind Hazard Reduction Program," *Journal of Professional Issues in Engineering,* ASCE, 121 (1), 1995, pp. 41–46.

Table 1. Main Components and Major Areas of Activities of the Proposed NWHRP

Understanding of Wind Hazards	**Assessment of Impact of Wind Hazards**	**Reduction of Impact Of Wind Hazards**		**Community Resilience, Education, & Outreach**
More Knowledge and Data on Severe Winds	Performance of Buildings, Structures and Critical Infrastructure Using Data Collection, Experimentation & Synthesis	Retrofit Measures for Existing Buildings, Structures & Infrastructure	Cost Effectiveness of Loss Mitigation	Community Resilience to Wind Hazards
Better Understanding & Quantification of Wind Loading on Buildings and Structures	Tools for Component and Structure-Level Simulation & Computational Modeling	Innovative Technologies for New Buildings, Structures & Infrastructure	Financial Instruments for Risk Transfer	Cross-Area Outreach & Education
Mapping of Wind Hazards	Tools for System-Level/Loss Assessment	Land-Use Measures	Emergency Response & Recovery	Education & Public Outreach

Implementation of the above concept is based on a sequential progression from Component A through Component D. Significant number of outreach tasks are planned to be activated at appropriate phases of progress in research tasks of all the components of the program, as is illustrated in Table 2.

Table 2. Breakdown of NWHRP by Research (R) and Outreach (O) Tasks

A	**UNDERSTANDING OF WIND HAZARDS**
R1	Enhanced Knowledge on Severe Winds.
R2	Understanding and Quantification of Wind Loading.
R3	Mapping of Wind Hazards.
O1	Enhanced Knowledge on Severe Winds.
O2	Mapping of Wind Hazards.
B	**ASSESSMENT OF IMPACT OF WIND HAZARDS**
R1	Structural Resistance Using Data Collection.
R2	Tools for Simulation and Modeling.
R3	Tools for System-Level/Wind Loss Assessment.
O1	Structural Resistance Using Data Collection.
O2	Tools for Simulation and Modeling.
O3	Tools for System-Level/Wind Loss Assessment.
C	**REDUCTION OF IMPACT OF WIND HAZARDS**
R1	Retrofit of Existing Buildings and Structures.
R2	Innovative Strategies for New Buildings and Structures.
R3	Land Use Measures and Construction Practices.
R4	Cost Effectiveness of Wind Loss Mitigation.
R5	Financial Instruments to Transfer Risks.
R6	Technologies for Emergency Response and Recovery.
O1	Codes, Guidelines and Demonstration Projects.
O2	Financial Instruments to Transfer Risks.
O3	Technologies for Emergency Response and Recovery.
D	**ENHANCE COMMUNITY RESILIENCE, EDUCATION AND PUBLIC OUTREACH**
	COMMUNITY RESILIENCE TO WIND HAZARDS
R	Research Addressing Community Resilience.
O	Outreach Addressing Community Resilience.
	EDUCATION AND PUBLIC OUTREACH
O1	Pre-College (K-12).
O2	College – Undergraduate Program.
O3	College - Graduate Program.
O4	Continuing Education.
O5	Public Awareness & Outreach.

In formulation of the NWHRP plan attempts were made to develop a dynamic program that would allow for timely use of outcomes of ongoing (in the United States and elsewhere) related research and outreach efforts addressing mitigation of losses due to wind and other natural hazards. A particular attention was given to activities in the area of earthquake engineering, carried out within and beyond the framework of NEHRP.

Potential Impact of Information Technology

Recent developments in information technology (sensors; data collection, transfer, processing and visualization; experimental and computational simulation; high-end computing; and adaptive networking) have a potential to lead to unprecedented breakthroughs in our efforts to reduce property losses and human suffering due to wind hazards. These advances in information technology (IT) have already significantly influenced activities addressing impacts of natural hazards. Two representative examples of relevance to the NWHRP are discussed below.

The first example is the Network for Earthquake Engineering Simulation (NEES). Significant federal investment has been authorized by Congress for the development of NEES—$82 million over the 2002–2004 period. This funding was allocated for construction/enhancement of engineering laboratories at fifteen universities and development of an advanced networked and grid-enabled experimental, data, and computational infrastructure. This resource makes possible implementation of a concept of "colaboratory" which enables researchers to remotely interact with each other and with their simulation and computational work via "telepresence" tools. Application of these concepts and infrastructure appears to have a great potential for breakthroughs in wind hazards research and outreach. Modest investment to upgrade wind engineering experimental (laboratory/field) and computational infrastructure, coupled with shared use of the NEES networking capabilities would allow for an efficient exploratory application of these technologies in the NWHRP activities.

The second example is utilization of low-cost, small-size (3 ft × 3 ft) networked radars that can be placed on existing cellular towers. These short-range sensors can provide information on low-level winds and other properties of the atmospheric surface layer. They are currently being developed by one of the Engineering Research Centers (supported by NSF) and they are scheduled to be tested in mid 2005, in a networked configuration covering approximately 20 percent of the State of Oklahoma. This technology appears to have potential for application in mapping of wind hazards and in other activities of the NWHRP.

Concluding Remarks

As discussed in this presentation, significant coordinated federal effort will be required to reverse trend of increasing property losses and human suffering due to wind hazards. The proposed research and outreach plan represents a comprehensive approach to this problem. Implementation of this plan through activities of the proposed NWHRP promises to have a very high level of success in achieving significant reduction in wind hazards impacts within the next decade.

Recent revolutionary developments in information technology (including sensors, data collection, transfer, processing and visualization, experimental and computational simulation, high-end computing and networking infrastructure) have a potential to lead to unprecedented breakthroughs in our efforts to reduce property losses and human suffering due to wind hazards. Sizing the above opportunities will require federal investment to upgrade the existing and develop new research and outreach infrastructure and human resources.

Reduction in material losses and human suffering within the next decade will not be possible without a significant and long-term federal commitment. Moreover, delay in adjustment in federal support in these areas will undoubtedly lead to further (and probably accelerated) deterioration in currently existing national research and outreach infrastructure and in human resources in wind engineering, wind hazards mitigation and in related disciplines.

BIOGRAPHY FOR BOGUSZ BIENKIEWICZ

Dr. Bogusz (Bo) Bienkiewicz is a Professor of Civil Engineering and Director of the Wind Engineering and Fluids Laboratory at Colorado State University in Fort Collins, CO. He holds a Ph.D. in Civil Engineering from Colorado State University. For over 25 years he has been involved in wind engineering research at the Wind Engineering and Fluids Laboratory and in teaching in the Department of Civil Engineering at Colorado State University. His professional service and outreach have included participation in various activities of the American Association for Wind Engineering and in technical committees of the American Society of Civil Engineers. He currently serves as President of the American Association for Wind Engineering.

Colorado State University

February 5, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on February 9th for the hearing entitled *Strengthening Windstorm Hazard Mitigation: An Examination of Public and Private Efforts.* In accordance with the Rules Governing Testimony, this letter serves as formal notice of the Federal funding I currently receive in support of my research.

- Amount: $25,000; Contract number: NA1341-02-W-1525; Sponsoring agency: DOC-National Institute of Standards and Technology; Contract title: *Wind Tunnel Study of Wind Loading on Low-Rise Buildings*; Contract start date: 9/26/2002; Contract end date: 7/31/2004.

Sincerely,

Dr. Bogusz (Bo) Bienkiewicz, Professor
Department of Civil Engineering
Colorado State University
Fort Collins, CO 80523
E-mail: bogusz@engr.colostate.edu
Ph: 970-491-8232 (Voice)

Mr. NEUGEBAUER. Thank you. Mr. Shofner.

STATEMENT OF BRYAN L. SHOFNER, PRESIDENT, SHOFNER & ASSOCIATES INSURANCE AGENCY, INC.

Mr. SHOFNER. Thank you, Mr. Chairman, Congressman Moore, for allowing me to be here today. It is truly an honor to visit with you on this matter. Again, as you said, my name is Bryan Shofner. I am the President of Shofner & Associates Insurance Agency, Incorporated. I am an independent insurance agent selling primarily property and casualty insurance for both residential and commercial clients. As an independent insurance agent I represent several insurance companies and place my customers' business with the company that best satisfies their needs.

I have been asked to testify on the status of wind damage mitigation research as well as what steps the industry has undertaken to reduce damage from wind. Insurance companies have significant information on risk factors as well as loss severity and loss frequency by a given area of the country, state, county, or city. Companies can determine the likelihood of the given loss, which is used in the calculation of the insurance premium that is charged to a specific policyholder or applicant for insurance. This statistical information is proprietary and intended for the sole use of that particular company to aid in the rate making process. On the other hand, insurance companies have very little information on wind damage mitigation techniques and do very little research on wind damage reduction. Insurance companies do not have the engineering staff to accomplish this research. The offshore reinsurance industry does some minor research, but this information is also proprietary.

There are other organizations that provide statistical and actuarial information, such as the Insurance Services Office. They provide this information to those companies who do not have their own data. ISO publishes information about loss costs for different types of construction, which insurance companies can use to determine appropriate rates. This organization also recommends specific credits be given for compliance with certain building codes or the use of materials such as window shutters.

There are also other organizations such as the Institute for Highway Safety and the Institute for Business and Home Safety that provide research for the insurance industry; however, these organizations have no budget for research for wind hazard mitigation to the best of my knowledge.

I do believe there are several universities that conduct research on wind damage and the ability of certain products to withstand damage from wind; however, I am not aware of any efforts by individual insurance companies or the industry to build on these efforts.

While I do not have access to specific loss amounts for wind damage, I can provide some insight into the amount of damage caused by hurricanes. Average annual losses from hurricanes in the United States are between $5 and $20 billion, using current property valuations and 2000 census data. This spread is due to the variance in modeling projections and building performance. In the last half century, Florida and Texas suffered the largest hurricane losses in the United States. Based on adjusted losses, 38 percent of the direct insured property losses caused by catastrophic hurricanes occurred in Florida, with another 11 percent in Texas. The most expensive windstorm in history, Hurricane Andrew, produced insured losses of $15.5 billion or approximately $20 billion in current dollars.

One aspect not often considered is the economic impact of windstorms on the community. A report commissioned by the Office of Florida Governor Lawton Chiles summed up the damage from Hurricane Andrew as follows: 28,066 homes destroyed, 107,380 homes damaged, 82,000 businesses destroyed or damaged, 7,800 businesses closed as of September, 1992, and 86,000 people out of work as of September, 1992.

The immediate financial and market consequences of a major catastrophe are swift, severe, and long lasting. Small insurers may become insolvent and the remaining insurers will most likely have limited resources to write additional risks or the market for residential and commercial properties may be non-existent. Catastrophe reinsurance process will increase and availability will be limited for some time. Business owners are often forced out of business with the additional loss of jobs to their employees and the loss of revenue on the economy.

Due to a lack of real data demonstrating that mitigation is truly effective, insurance companies have been reluctant to provide insurance incentives for mitigation; however, changes are beginning to occur with Florida and Texas mandating incentives for certain mitigation techniques and/or compliance with stringent building codes found in catastrophe-prone areas. The Texas Wind Storm Insurance Association provides discounts for specific features in homes in designated catastrophe-prone areas.

New homes will fare better in windstorms, although much more still needs to be done. The new International Residential Building Code has better loads and a wind-borne debris region, but lacks many basics. Cost effective measures for new homes should include secondary water resistance, improved roof coverings, improved design loads for two and three-story buildings, treatment of soffits in design and wind borne debris. Failure of states to adopt stringent building codes, such as the IRC, as mandatory for all areas of the state will continue to result in wind damage that could have been less severe or possibly avoided all together.

Retrofitting is rare except in those cases where a loss has already occurred and the home is being repaired and new building codes have been adopted. Insurance incentives, public education, and statewide stringent building codes can help remedy this situation.

Barriers to widespread implementation of existing mitigation techniques include lack of education, failure of insurance companies to provide sufficient financial incentives, knowledgeable construction personnel, cost to the homeowner, and again, lack of mandatory building codes. Changes through zoning restrictions or building codes are often opposed by developers, homeowners, real estate, and even local government who are concerned with the increased cost of construction.

Most coastline states are still susceptible to significant devastation, including both property and non-property losses from a major windstorm. Unless state-wide risk reduction strategies, including stringent building codes and building moratoriums in those areas most vulnerable to wind damage occur, wind damage mitigation will not succeed in protecting from loss of life and property.

Again, thank you for the opportunity to be here. I do appreciate this.

[The prepared statement of Mr. Shofner follows:]

PREPARED STATEMENT OF BRYAN SHOFNER

Mr. Chairman, Members, my name is Bryan Shofner and I am the President of Shofner A& Associates Insurance Agency, Inc. I am an independent insurance agent selling primarily property and casualty insurance for both residential and commercial clients. As an independent insurance agent I represent several insurance companies and place my customer's business with the company that best satisfies their needs. I have been asked to testify on the status of wind damage mitigation research as well as what steps the insurance industry has undertaken to reduce damage from wind.

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On the other hand, insurance companies have very little information on wind damage mitigation techniques and do very little research on wind damage reduction. Insurance companies do not have the engineering staff to accomplish this research. The offshore re-insurance industry does some minor research but this information is also proprietary.

There are other organizations that provide statistical and actuarial information such as the Insurance Services Office. They provide this information to those companies who do not have their own data. ISO publishes information about loss costs for different types of construction which insurance companies can use to determine appropriate rates. This organization also recommends specific credits be given for compliance with certain building codes or the use of materials such as window shutters.

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Most coast-line states are still susceptible to significant devastation including both property and non-property losses from a major windstorm. Unless state-wide risk-reduction strategies including stringent building codes and building moratoriums in those areas most vulnerable to wind damage occur, wind damage mitigation will not succeed in protecting from loss of life and property.

This concludes my remarks and I would be happy to answer any questions that you may have.

Biography for Bryan L. Shofner

PERSONAL HISTORY:

Birth date: Born March 17, 1965 in Lubbock, Texas

Marital Status: Married (13 years)

Family: Wife, Diane, with two sons, Taylor (Age 12) and Landon (Age 6)

EDUCATION:

License:

Currently hold Texas Local Recording Agents and Group I Licenses

Currently hold Non-Resident Licenses in New Mexico, Colorado and Kansas

Designations:

Currently pursuing Certified Insurance Counselors (CIC) and Accredited Risk Manager (ARM) designations

Achieved Commercial Lines ACSR Designation in 1993

College:

Baylor University—Texas Local Recording Agents (Ninety Classroom Hours)

Texas Tech University—1983–1986 (Majored Psychology)

High School:

Coronado High School (Graduated 1983)

WORK EXPERIENCE:

Firm: Shofner & Associates Insurance Agency, Inc., 5106 Slide Road, Lubbock, Texas 79414

Position: President

Duties: Officer and Manager

Length of Time: June 1986 to Present

AWARDS:

Texas 2001 Young Agent of The Year—Presented by the Independent Insurance Agents of Texas and Travelers Property & Casualty—2001 IIAT State Convention (San Antonio, Texas)

Recognized as a Leader in the Industry—2001 IIAT State Convention (San Antonio, Texas)

PROFESSIONAL ACTIVITIES:

- Currently serving on the Board of Directors for the Independent Insurance Agents of Texas, 2002–2005
- Served on the Texas IIAT Legislative Committee, 2000–2001
- Texas State Chairman for the Independent Insurance Agents Junior Golf Classic Committee, 1999–2001
- Ex-Officio Board Member for the Lubbock Association of Insurance Agents, 1998–1999
- President of the Lubbock Association of Insurance Agents, 1997–1998
- President-Elect of the Lubbock Association of Insurance Agents, 1996–1997
- Vice President of the Lubbock Association of Insurance Agents, 1995–1996
- Board Member of Lubbock Association of Insurance Agents, 1994–1999
- Currently serving as the President-Elect Community Health Center of Lubbock
- Treasurer Community Health Center of Lubbock, 1997–2000
- Board Member of Community Health Center of Lubbock, 1996 to present

SHOFNER & ASSOCIATES INSURANCE AGENCY, INC.
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January 29, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert,

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on February 9th for the hearing entitled Strengthening Windstorm Hazard Mitigation: An Examination of Public and Private Efforts. In accordance with the Rules Governing Testimony, this letter serves as formal notice of the Federal funding I currently receive in support of my research.

Please note for your records I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two proceeding fiscal years.

Sincerely,

Bryan Shofner

Casualty • Home • Auto • Life

DISCUSSION

Mr. NEUGEBAUER. Thank you, Mr. Shofner. We will now have a question and answer period and I will start off with Dr. Kiesling.

Texas Tech is obviously a leader in windstorm hazard mitigation research and development, from providing information to the public on how to stay safe during a tornado to developing an in-house residence, safe houses. Texas Tech's contribution in this field has been invaluable. What processes are in place at Texas Tech to transfer the technology knowledge developed at the Wind Science and Engineering Research Center to other research institutions, government industries, and the public?

Mr. KIESLING. A multitude of things would be in line with that. First of all, we produce a significant number of publications, as you would expect. Those are available on our web site and distributed. A lot of them are presented at meetings. We have an information, an outreach program. We answer an enormous number of telephone inquiries from all segments of the industries—the builders, the producers, the public. We regularly teach short courses to, for example, the American Society of Civil Engineers. We had a three-day short course in this building last week with design professionals. There are various outreach programs, a lot of educational programs with K through 12, though our ability to do that depends a lot upon the personnel we have available to do that. So there are a number of mechanisms in place.

Mr. NEUGEBAUER. Okay. Thank you. This is kind of a question for all of you. In reading your testimony, you know, one thing that became evident was that a lot of the research, or research dollars that you perceive being allocated by the Federal Government is going more to the weather, study of weather patterns, and certainly that is an important part of that, but the mitigation area probably is getting some of the least amount of funding. And so your feelings as to how, if you are allocating from the study of the atmosphere, the mitigation, and then the implementation, what is your feeling on how that pie should be divided?

Dr. Meade.

Dr. MEADE. You are correct that most of the money is going toward weather forecasting, and studies are a part of that. It's not clear so much that it is a pie to be divided in the sense that you could take the same amounts of money that you're ordinarily giving to hazard mitigation simply because it may cost more money to do that sort of research than it does—for example, it requires satellites and all kinds of expensive instrumentation. So, it's not clear that you can make a dollar for dollar comparison. The point being, if loss reduction is your goal, loss reduction being measured in terms of dollars, the only way you are really going to do that is if you focus on research that sort of feeds into programs such as those here at Texas Tech or other engineering programs. And weather forecasting programs are largely focused on helping people make very short decisions, like whether to evacuate before a tornado or before a hurricane. The data that is collected in weather forecasting programs is generally not used in an engineering context. At least, that is not why it is being collected in the first place. So a lot, I think, you could certainly increase the amount of money that is going toward the engineering side and largely because the ratios are so imbalanced right now it would be awfully hard to make a contribution error. I think it would make a very large contribution to loss reduction.

Mr. NEUGEBAUER. Dr. Bienkiewicz.

Dr. BIENKIEWICZ. Well, the level of support of engineering activities, as stated by witnesses here, is low as compared to the level of funding of phenomenon itself. I would like to say that technologies which could be incorporated in such a way that the costs of providing more information on phenomenon for direct application of engineers would not be prohibited. And in my testimony I am quoting an example of the project which states that being developed by Engineering Research Center founded by National Science Foundation and people are thinking about placing a small-site radar system, and the place specified for this project will be in Oklahoma. So there are opportunities, and that is what I tried to state in my testimony, of high technology dropping costs of doing science and providing information for engineering complications. So that might be one of the options which we should actively pursue.

Mr. NEUGEBAUER. My time has expired. The gentleman from Kansas.

Mr. MOORE. Thank you, Mr. Chairman. First question to Dr. Kiesling. You talked about safe rooms and I guess my question to you, sir, is can you give us an estimate, percentage-wise or dollar amount, what it might cost to build a safe room into a home to protect the occupants from death.

Dr. KIESLING. Yes. I would say that the low end of a quality shelter, one that is really dependable, would be approximately $3,000. They go up from there and it depends a lot on whether you are talking about new construction or retrofit because in a retrofit costs vary because of accessibility problems and so forth, but I would say from $3,000 to $6,000 is a reasonable estimate of the range.

Mr. MOORE. And in terms of retrofit or new construction, what kind of techniques or technologies would be incorporated to protect people in a safe room.

Dr. KIESLING. In the case of new construction, of course, the ideal situation is to simply choose a small room such as a bathroom, a closet, a pantry, and harden and stiffen that to provide the level of protection desired.

Those are designed so that they would provide protection even if the house is totally destroyed.

In a retrofit situation there are concepts where you could improve the same room. The critical thing is to have a foundation to which to anchor, or a slab. But an economical way in a retrofit situation is simply to put a shelter, build a shelter down in the garage, a steel box if you will, and there are many products on the market now available for that. And so that is probably the low end of the cost range as well because you can buy a manufactured shelter and simply anchor it and it will provide good protection.

I would also distinguish between the in-residence shelter. That is one that is accessible without going outdoors. Many shelters are being built as say cellars or dugouts in the back yard. Certainly they offer good protection if you are in them, but you need to use them in a different way. In other words, you need to access those when there is a weather warning because if you wait until the storm is in progress, then you would probably take greater risk to get to it than just staying indoors.

Mr. MOORE. So early alert makes a big difference.

Dr. KIESLING. It does in that type of shelter, yes. Of course, in the case of community shelters, that is particularly true because one has to have sufficient notice to get to the shelter.

Mr. MOORE. Dr. Kiesling, thank you, sir. Dr. Meade, you indicated—and I wrote this down and this is not an exact quote, but correct me if I am wrong, but I think it is close to what you said—injury rate for manufactured housing buildings is 20 times higher.

Dr. MEADE. These are data from scientists at NOAA, the National Oceanographic and Atmospheric Administration, and in looking at injury and death rates from tornadoes specifically and looking at the history of the death rates from tornadoes over the past century or so, in recent years they estimate that the death rate for manufactured homes is 20 times higher than that from conventional homes, yes. I can send you a detailed reference of that, if you would like, sir.

Mr. MOORE. Thank you. Mr. Shofner, in your testimony you talked about hurricanes and not as much about tornadoes and I think you indicated that you didn't have as much data; is that correct?

Mr. SHOFNER. Yes.

Mr. MOORE. Does your industry generally view these two types of storms differently? If I am in Lubbock, Texas, or Kansas City can I purchase coverage for tornado damage without purchasing coverage for hurricanes?

Mr. SHOFNER. Well, the hurricanes, normally that coverage is normally directed toward property that is located in tier one and tier two counties. That is what we refer to as coastline and just inside the coastline.

Mr. MOORE. Okay. So I guess the answer is yes.

Mr. SHOFNER. Yes.

Mr. MOORE. All right. If the Federal Government were to fund a serious program for wind hazard research and reduction or mitigation of damages, do you believe insurance companies would really use that information——

Mr. SHOFNER. I believe they would.

Mr. MOORE [continuing]. In setting rates?

Mr. SHOFNER. Yes, I believe they would. One of the things that you would have to keep in mind is obviously—and I have discussed this, touched on this—is that the cost of construction to meet these qualifications, obviously from an insurance standpoint, we have to insure reconstruction costs. So naturally as that cost of construction increases, the premiums increase. But your overall incentive, I think, is underlying in that it makes the risk actually more marketable to the insurance companies for their most aggressive rates that they have.

Mr. MOORE. Thank you. Mr. Chairman, I have one more question. My time is up, but can I ask one more question.

Mr. NEUGEBAUER. Sure.

Mr. MOORE. I think one of you mentioned—I don't know who it was and please, whoever knows this information, if you do, jump in—that there was a lot more research money devoted toward hurricanes than tornadoes—I'm sorry, earthquakes than tornadoes. Did somebody talk about that or did I read that in some of your materials?

Dr. MEADE. Actually, in the RAND study we pointed out that roughly 85 percent of all the funding went toward weather-related hazards and the second part was kind of gray. It was educational, and that's an order of magnitude less than the weather-related hazards and so the difference, of course, between earthquakes and weather is that there is no earthquake prediction going on, but there is a lot of weather forecasting work going on.

Mr. MOORE. Okay. Thank you, Mr. Chairman.

Mr. NEUGEBAUER. Prior to lunch today we had the opportunity to go out and tour a reinforced home under construction and then we visited one that was completed and during that process the builder of that home was at the site and it is about an 1,100 square foot home and the perimeter walls are foam forms with concrete poured in the center of those foam blocks. In this facility it also had an in-home closet for a tornado shelter. The approximate cost of that was about $9,000 over conventional construction and one of the questions that we began to talk about during that process was, you know, what kind of recognition is there in the insurance industry for the fact that this house is much more fortified, wind resistant, and storm resistant than the house sitting next to it? And one of the ladies there that administers the program at the City Community Development said that they had to shop around and could not really get a quote that would give any recognition for that until after they had made some calls to another part of the country where they had been doing some homes like that and were able to identify a company that would write that. Because the important part of that, when you take that $9,000 and amortize it in today's rates, that is probably a four or five—a $50 or $60 increase in the payment. Maybe not that much at these rates, but one of the things that she said when they finally did get an insurance quote, that it was about 50 percent of a conventional quote for the homes, conventional construction.

I think one of the things that is the secret to us really getting some meaningful research and development is getting the recognition in the market place that this kind of mitigation should be taking place and that there is a reward for the homeowner that says, you know, I am going to buy the more fortified home and the way I am going to pay for part of that—maybe it doesn't amortize all of it, but possibly it could, depending on the interest rates and so forth. Mr. Shofner, what do you see as far as recognition of, for example, some of the coastal areas and bringing into some mitigation efforts in the insurance industry rewarding that?

Mr. SHOFNER. Well, I think one of the things that would have to be done initially is that there would have to be some education put in place to, obviously, consumers, but also the companies. Just recently most everyone in the State of Texas is aware of the fact that they gave—they have allowed for a credit for different types of hail resistant roofs.

They classify a specific roof based on what you would place and they will give a credit based on that roof if they have filed with the state to offer that credit. That's the other thing why a tie to educating the companies, is that the more information that they have that is being done to mitigate these types of losses, then they can go in and make an effort to make a filing with the Department of Insurance in the state that they are located in to offer an appropriate credit for what they are doing.

Mr. NEUGEBAUER. And one of the other things, I think in testimony, and maybe it was yours or somebody else's, we were talking about who's doing research in this and it looks like most of the research is falling upon the Federal Government right now. The insurance industry within itself is really not doing much research and yet we also hear that they're reluctant to share some of their loss data with researchers that are actually doing that. What kinds of things do you think we can do to bring together—I am a great believer in public/private partnerships because my experience is when things are just in the private sector, I mean just in the public sector without private sector participation, they are slower to get off the ground because ultimately the goal here is some commercialization of the research that is going on here. How can we foster that?

Mr. SHOFNER. That is a tough question. I think when we have the answer to that, then we will have achieved a lot in overcoming the issues that we are talking about here today.

I could probably—Do you mind if I defer to a gentlemen to ask a quick question.

Mr. NEUGEBAUER. Sure.

Mr. SHOFNER. I apologize.

Thank you very much for allowing me to do that. One thing we could do is determine, show the company, and like I said this goes back to the education of the companies. If we can show them how they can save in a specific area by giving these credits over the long haul, I feel like that they would become more aggressive in their approach to offering these credits, if they see what other companies are able to do and how much money they are actually able to save as these storms occur.

Mr. MOORE. Okay. Thank you, Mr. Chairman.

Maybe it was you, Dr. Bienkiewicz—if it was somebody else, forgive me—but you testified or I read in the materials that a significant portion of the loss, the economic loss, will come from interruptions in business operations. Did you touch on that in some of your materials?

Dr. BIENKIEWICZ. Yes.

Mr. MOORE. What can we do, if anything, to guard against that, protect against that economic loss from interruption to business?

Dr. BIENKIEWICZ. There are several elements which one should refer to. First of all, mitigation measures before it even happens so that there are no interruptions in business. One of the examples which we are facing, that was approached by the state agencies in one of the western states, is that frequently transportation is affected by high wind effects and then the transfer of goods from West to East Coast is really suffering because of costs. So there are regional issues which state agencies and businesses are facing and I suppose if the region beyond hurricane and tornado alleys and hurricane zones would be identified if we want true, true mitigation of a lot of our problems, that would significantly minimize professional exceptions to business and examples of application.

Mr. MOORE. Thank you, sir. Dr. Kiesling and anybody else who wants to join, if you have something to offer here, I would like to hear your thoughts as well. We talked, one of my earlier questions you answered about safe homes for private homes. What about people, low income folks who live in our communities? What do we do to protect low income people who can't afford the $3,000 to $6,000 for either new construction or retrofitting? How do we protect those folks?

Dr. KIESLING. This is a real challenge and unfortunately some of them live in the most vulnerable homes so that the community shelter offers one solution. And we are seeing, particularly in your state, more and more community shelters being built in schools and in manufactured housing parks. I think Wichita probably has one of the only ordinances that requires the construction of community shelters in manufactured housing parks and many of those low income people live there. There is no simple solution I know of to that. Though I would also remark that the incentive grants have a tremendous stimulus to shelter construction and certainly anyone can offer, can get the protection fairly economically. It may not be the most aesthetic thing, but after the Oklahoma City tornadoes, for example, and the incentive grants there, many people just bought concrete boxes to sit in the back yard. They are not optimum, they're not ideal, but many people were in there when the next tornado came through and they performed okay. So there are more economical shelters available and furthermore the small incentive grants can make a great deal of difference in making them available.

Mr. MOORE. Incentive grants from the government?

Dr. KIESLING. Well, of course, most of the stimulus has come to date under the Stafford Act after a disaster when a percentage of the relief and recovery funds go into mitigation and the states have chosen to make incentive grants available. In some states, Arkansas for example, the state annually appropriates money for shelter incentive grants and they make small grants, a thousand dollars, but they always have more takers than—so they might come from anywhere, but certainly I think that is an area in which the states could be more active.

Mr. MOORE. You mentioned construction of these safe homes or some sort of community shelter in some of the manufactured home places. You mentioned the Wichita thing.

Is that happening in other places around the country?

Dr. KIESLING. Not to the same extent that I know of. I would also mention there that I understand that a bill was just signed into law in December.

Mr. MOORE. Okay.

Dr. KIESLING. That HUD will provide monies for shelter incentive grants. It's not a large amount of money, but it is a beginning and that can be very significant and I think they are aiming at the low income families.

Mr. MOORE. Thank you, Dr. Kiesling. May I have one more question, Mr. Chairman.

Mr. NEUGEBAUER. Yes, sir. Go ahead.

Mr. MOORE. Obviously the last two years we thought a whole lot in this country about homeland security. How does that tie in or can that tie in with some of these safe homes and other things? Is there a way to make dual use of that? Anybody?

Dr. KIESLING. Well, we think so; that is, the safe room, for example, can readily be retrofitted to protect against chemical and biological hazards, relatively inexpensively, I think. I see some potential for that. They are also, of course, much more resistant to blast, but I don't see that as much of an advantage in our residence. I'm not likely to have a warning when a blast will come. So I think there is some cross-advantages there that can be taken advantage of.

Mr. MOORE. Thank you, Mr. Chairman.

Mr. NEUGEBAUER. Yes, sir. One of the things that was, I think, a common thread in your recommendations as each one of you talked about where we go from here and I think one of those was, you know, a more organized structure for the research and development that is going on right now. We had a little bit of discussion back at our lunch table today and that really kind of maybe goes to the point of, if we move forward from here with some meaningful research dollars, you know, what is the best oversight agency for this type of research? Dr. Meade.

Dr. MEADE. Well, that is a difficult question because you have—you generally have agencies that are doing research right now and that would primarily be the National Science Foundation and NIST, the National Institute of Standards and Technology. Does that translate into the best agency for the oversight? I'm not sure. And so, you know, going to the NEHRP problem, you have FEMA as the oversight agency, but of course there are no R&D dollars whatsoever within FEMA. Maybe a similar structure would be appropriate, but a lot of this gets into goals that you hope to accomplish in this research program. In other words—and you talked yourself about what do you want the outcomes to be in five to 10 years. So sometimes gaining the outcomes might require a different agency to carry out the oversight function as opposed to those who are executing them, the actual R&D mission. A safe bet is that there will probably be more than one agency involved and so the question is how do you coordinate it.

Mr. NEUGEBAUER. Dr. Bienkiewicz.

Dr. BIENKIEWICZ. It is my understanding that there is already discussion on the authorization for NEHRP, recent discussion in the House, but the need to put out with the NEHRP was moved from FEMA to NIST and as far as I can understand from discussion, a different region of FEMA now being under Homeland Security Department, but also from my perspective, NIST probably is on the side of implementation and codes and standardization so, of course, it seems to be an appropriate place, but it is tough for me to make.

Mr. NEUGEBAUER. One of the things I think—and I think you mentioned two agencies. One of the things that, and this is a personal opinion, is that when we get multiple agencies overseeing, sometimes when we just have one agency overseeing things it is onerous, but if you really want something to get real onerous, you assign multiple agencies.

Mr. MOORE. Just your personal opinion? A lot of people share that.

Mr. NEUGEBAUER. And the other thing is too, if we start getting two or three different, you know, groups in and they may have different committee oversight and then first thing you know, we can't trace where the money is going, there is no accountability, and so it is my personal opinion that we identify an agency and task them with a broad task of, you know, talking about, you know, from kind of A to Z, from the research to the implementation and actually the commercialization of that. And I would task that agency that we have to have the private sector at different levels. And I know that some of the research that Texas Tech has done, I think the National Building Institute, the homebuilders at the national level, getting some money to or toward some granting opportunities, are working in connection with that.

I think you have to bring all of those people to the table if you are going to get an outcome that will be accepted in the market place. Ernie, you want to reflect on that?

Dr. KIESLING. I was simply going to suggest, in answer to your earlier question, that to me a critical element is the language of the bill creating this thing so that the agency administering it has the ability to respond to the broad spectrum of research that needs to be done and is not limited by their mission. My sense would be that you can take care of a lot of that in drafting the language of the bill itself. I've read the House Bill 2020 and I think it does cover a lot of areas and would enable whatever agency to put it, to sponsor the kind of research that needs to be done.

Mr. NEUGEBAUER. Anybody else.

Dr. BIENKIEWICZ. I think that some of these issues were addressed in Bill 2020 and cross-integration of the activities and the agencies.

Mr. MOORE. Kind of getting down to nuts and bolts for just a minute. We've talked covering a number of different areas here, but I guess I wanted to ask, just in terms of what people, individual homeowners might do, either in retrofitting or home builders of new construction, what techniques are available to build stronger homes that will withstand wind damage and is it cost effective? Are people just spending unnecessarily if they try to put a few extra dollars into strengthening roof systems, for example, or walls? Can somebody talk about that? Is it going to keep claims from being made, is it going to be recognized by the insurance industry as we might not have to pay as much money out in a situation like this and therefore rates are going to go down? Dr. Kiesling.

Dr. KIESLING. I think that is an appropriate challenge for the research community and then we can say that there are some measures, more if you've got connections, stronger connections of roof to wall, wall to floor.

Mr. MOORE. Connections in what respect? How would that happen?

Dr. KIESLING. Well, there are so-called hurricane clips that you can use and they would work well in any kind of wind and those are so economical and so easily done that there is little question, I think, about the long-term economic benefit of that.

Mr. MOORE. If they are so economical, why wouldn't people in wind territories now be using them?

Dr. KIESLING. They do use them pretty extensively in hurricanes because there the public is convinced of the high probability of occurrence during the lifetime of the house.

In the tornado regions, again they are not that convinced of that, but I think it is the research community's challenge and obligation to provide reliable data and it takes a long time to accumulate that because you have to have an event before you can assess the effectiveness of it, basically, or verify the effectiveness of it. But I think we need to get reliable information to the homeowner and to the insurance companies as to what is the benefit and that is a big challenge. And it depends obviously upon the locale as well, the probability of the occurrence of a wind event. So if we go on a scale, we can readily say that some things we know are now effective, but other measures we would have to do some research to be able to say what is the effectiveness.

Mr. MOORE. Anybody else have a comment on this?

Mr. SHOFNER. I would agree with Dr. Kiesling. I mean, I think it would just take a lot of research efforts to be able to provide information to the insurance companies and put that information in front of their actuarials where they can properly look at it and see what the actual claims dollars that are going out to those loss site areas for homes that maybe aren't retrofitted or constructed to that quality as compared to the ones that are. And then over the time period, hopefully they would be able to see a necessity and see the advantages of being able to offer those credits.

Mr. MOORE. Dr. Bienkiewicz.

Dr. BIENKIEWICZ. Yes, I would like to extend this discussion to beyond single-home dwellings and into engineered buildings. If we need to begin in hurricane regions, they have none of the systems which allow you to reduce net load impacting components of buildings. When you make a single-family move, you have reduction and you can design a retrofit roof which will perform well and will meet current specifications for a region. So the need is urgent and I think we need to invest more money to improving them.

Mr. MOORE. Dr. Meade, anything?

Dr. MEADE. I don't think I have anything.

Mr. MOORE. I guess not to push, but to push a little bit, we have been having hurricanes and tornadoes for a few years around this world and we have been, people have suffered a lot of losses, including loss of property and loss of life. Is there any way to expedite this process? How do we hurry this up so we can save more dollars and lives in the future. Anybody? Yes, sir, Dr. Meade.

Dr. MEADE. I offer the opinion that if you can make it so that people can benefit more, even though the hurricanes and tornadoes do not occur every year, as Dr. Kiesling pointed out that the working probability is that a hurricane will hit a house once in its lifetime, but even so, that is a difficult catalyst for most homeowners and so you really need to see it reflected in a month to month or year to year basis in their insurance premiums so that it is in their economic interest to——

Mr. MOORE. So it comes down to money, doesn't it?

Dr. MEADE. It totally comes down to money.

Mr. MOORE. Well, we don't have that problem in Congress, I'll tell you.

Mr. NEUGEBAUER. I think to continue the dialogue we have been having, I think where I am personally, coming from the private sector for a number of years before getting to Congress is, you know, you have got to have an entrance strategy and then what we call an exit strategy. I think what the Congressman was talking about, what is our exit strategy here, when do we get to the point where we have some stuff that is cost effective that we can implement and we can get that information out to the private sector so they can start building and implementing this on a broader basis? I know we are building homes today in Lubbock with the in-house shelter that Dr. Kiesling has been working on, but I don't know how much retrofitting we are actually doing and probably the retrofit is probably the bigger piece of the pie. Certainly from this point forward, the new construction, it is easy to do that, but what kind of research are you doing on mitigation structures that, I don't want to oversimplify it, but you are almost going to have to, to me, to get it where you can go down to Lowe's or one of the building supply places and get a kit that that homeowner can take home and install in their home or get installed on a relatively inexpensive and quick basis without this major, you know, reorganization of their home.

Dr. MEADE. Your comment is correct that it would be a lot easier if you could go down to Lowe's and buy something off the shelf, ideally something that would come, for example, from the recent program that you are talking about. But it does come down to dollars and cents. For example, you can go down to Lowe's right now and you can buy insulation, which you will put in your house and which will decrease your energy bill. People will do that because they can see that it does decrease their energy bill. They don't go and buy insulation as part of being a good citizen. So the idea is there needs to be some mechanism in place for them to go down and make this investment in wind mitigation technology that it will have some sort of payback to them and payback has to hopefully occur before the next tornado or before the next hurricane because if you are waiting for them, if they are making a bet, so to speak, that a hurricane is going to occur, a tornado is going to occur next year, that's—not too many people are going to purchase it, no.

Mr. NEUGEBAUER. Go ahead and then, Ernie, we will to go you.

Dr. KIESLING. I think another difficulty there is that how can that benefit come without say a reduction in insurance premiums and how can the insurance company assess the value of that investment or improvement made? So that is a difficult thing to do and I guess education is the answer we would give to nearly all questions. But as you mentioned, it comes down to economics in the end and it may be unrealistic to expect the scenario that you just presented.

Mr. NEUGEBAUER. Mr. Shofner.

Mr. SHOFNER. I also believe if there were stricter building codes that were mandated, I think that insurance companies would see that information as a positive step and I think they would move quicker from that standpoint to react to what people are doing proactively to try to limit their losses and I think in return they would go out and try to see what they could do from an incentive on the other side. I think it would just be a quicker step.

Mr. NEUGEBAUER. Well, I know that the insurance company is recognizing, for example, I think if you have a certain kind of lock, dead bolt locks, and if you've got an alarm system in your home, now we've gone to roof structures, I mean, so it is not, we are not setting any precedent here.

But what I heard you saying earlier is that there is really not tangible evidence, or the perception in the industry is that there is not tangible evidence, that insuring house 541888 and 542088 and one of them has, you know, a different structural, a more rigid structure, that it is less of an insurance risk than the one next door that is conventional, that there is just not recognition in the marketplace.

Mr. SHOFNER. Currently right now there is not, unless it is a large difference in risk. When you are talking about two homes that are right next to each other, in my opinion, no, there's not, but if you have a home that is inside the city limits from versus one that is just outside the city limits, that could create a difference there because——

Dr. MEADE. Well, maybe known to several parts of the insurance industry. It is certainly not known to homeowners, but it is known, for example, that if you go out and buy a red sports car, you are going to pay more insurance than you are if you are going to go out and just buy a standard sedan of some sort. Or you know that if you have young children who are driving in your household, your insurance rates go up.

Mr. NEUGEBAUER. I have experienced that, both the red sports car and the children.

Dr. Bienkiewicz, did you want to add anything to that?

Dr. BIENKIEWICZ. I would like to make a comment about a national program which I developed which would help out industry as well as practicing engineers. And I brought with me, it is an older version of the NEHRP provisions. This is one volume. There is another volume coming and it has been revised several times. It is a tangible product coming from that program. It provides bolts and nuts related to design and details and so on and so forth. Now when we talk to practicing engineers, there are some codes, and there are some others, so we can provide the toolboxes. This is one of the examples.

Mr. NEUGEBAUER. Would you like to enter that as part of your testimony?

Dr. BIENKIEWICZ. Yes.

[*Note:* Information referred to is "NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures," 1997 ed., Part 1: Provisions (FEMA 302), http://www.bssconline.org/pdfs/fema302a.pdf]

Mr. NEUGEBAUER. Okay. That would be fine. My time is up.

Mr. MOORE. Thank you, Mr. Chairman. Some have alleged and I think we have made reference to this without—I guess we have mentioned the number, but HR 2020, Hurricane and Tornado Related Hazards Research Act Summary, and the Congressman here is one of the co-sponsors, as are many of the Members of Congress here in Texas, in Kansas, and other places where you would expect to have wind damage. And I guess I would ask all of you, if you have national associations—I know some of you certainly do—to contact your national association and ask some of the Members of Congress to sign on to this because if this gets passed, what it does, obviously—there is a handout back there somewhere as to the bill and shows the current bill sponsors on there—but it requires the Director of the Office of Science and Technology Policy to establish an interagency group to be responsible for the development and implementation of a coordinated hazard reduction and research development and technology transfer program to achieve major measurable reductions in losses within 10 years. And it is interesting to me to hear representative Shofner from the insurance industry here talk about the need for stricter code standards. And sometimes people get upset when Congress or other governmental agencies mandate additional regulations or requirements, but, I mean, there is, maybe we have to balance it out and work it out here. By the same token, I guess, we would, I think, really like to see—this is certainly not a shot at Mr. Shofner—we would like to see the insurance industry moving in this area and doing their own research as well, coming up with answers to some of this. And if the information is available and it does warrant a reduction in premiums for insurance, then if the insurance industry recognizes and conveys the information to the homeowner, or other people, that you are going to get a reduced premium if you do these things in construction or retrofitting, then it might well be worth it and we all save money and more importantly, lives, because we can replace property, but we can't replace lives. Any other comments on that? I'm not trying to lecture here. I'm just—we are having a discussion, I guess.

Dr. KIESLING. I would simply repeat my earlier point that any incentive is highly significant in terms of improvements. And we've seen where over and over, shelters and other things, where any time we can offer an incentive of any type, be it in financing, be it in cost reduction of operation, participating in the initial cost, whatever it is—another tax abatement is working pretty well in some areas, where say the cost of improvement is not taxed and so forth—and so I think whatever can be used—I think maybe what may be more significant than the dollar value of that is the educational value of letting the customer and the homeowner know that there is a benefit to their making that investment.

Mr. MOORE. Mr. Chairman? Any questions.

Mr. NEUGEBAUER. You know, we are having this dialogue, and as I was reading the testimony, a couple of things kind of started crystallizing for me. As we look at the mitigation aspects of it, we have life and we have property and in Ernie's, Dr. Kiesling's safe house or safe room, you know, the primary emphasis there is life. And because in a major tornado, I don't know what, and maybe you have done some testing on these reinforced concrete houses, how much that structure survives in a tornado. In a hurricane, though, the structural aspects of it seem to be easier to mitigate, are more mitigatable than, you know a category 4–5 in a tornado. So you begin to put that research together.

Do you see different goals and objectives in the hurricane side as you are doing the tornado side? Obviously, up to a certain level of winds, on the perimeter of the tornado, you are dealing, you know, with the same wind issue. Are there different goals in some ways there?

Dr. KIESLING. Well, certainly there are differences and I would suggest that in tornado regions, perhaps more important than loss of life is the reduction in anxiety. Because when you look at the statistics, the number of deaths from tornadoes is significant certainly, and we want to save those lives, but I think a much greater cost might be the anxiety and the loss of productivity, the health problems and so forth created by the anxiety. And so I think that is a strong justification for the safe room. Whereas in a hurricane region, it is much more of a reality that it is going to occur. And I think there are differences in requirements and design criteria and we have a long ways to go in optimizing the designs of buildings and shelters for the particular application. Shelters have not been popular until recently in hurricane regions and so I think we will see a lot of evolution there in the next few years. I am walking all around your question, but I—certainly there are many similarities and differences, but I think the objectives are somewhat different in the economics of it because of the higher probability of occurrence in hurricanes.

Mr. NEUGEBAUER. Dr. Meade.

Dr. MEADE. Well, you simply have much more time to contemplate the hurricane than you do the tornado and so people know about advancing hurricanes usually 48 hours, 72 hours beforehand and so all kinds of actions are taken to prepare themselves. As Dr. Kiesling was pointing out, the really frantic, last-minute preparations that are taking place for a tornado and you are basically trying to save lives if it is bearing down hard enough.

Mr. NEUGEBAUER. Yeah, I was just thinking that, and this is in very simple terms, so if I live on the coast, what I am thinking is I am working at my house and I'm nailing up the shutters and I'm putting the plywood up there and really what I am worried about is—I'm going to evacuate—what I am worried about is when I come back, you know, how much of my personal belongings or my home is going to be intact?

Dr. MEADE. But you can do that because of the nature of the events, right.

Mr. NEUGEBAUER. But with a tornado, I only really have one thing on my mind and that is my personal safety, you know, because, as Ernie says, it is a quick event, it is going to be intense, most likely, and then it is going to be over and I would think that most people, when they go to a tornado shelter, are not worried about whether their house is going to be—I mean it's certainly a thought, but they are more concerned at that moment of their personal safety.

Dr. MEADE. Right. The economic losses from tornadoes is still quiet significant. Again, whatever differences between mine and Mr. Shofner's testimony can only be indicative of the difficult state of the data on this problem, but the estimated annualized losses of hurricanes are more than $5 billion a year and those for tornadoes only were at $1 billion a year so it is still a big number.

Mr. NEUGEBAUER. Still a big number.

Dr. BIENKIEWICZ. I would like to make a comment that the majority of tornadoes are not extremely strong so if you look from a statistical point of view, we could reduce the amount of damage of tornadoes. I took part in a field trip last year in Kansas. Saw several tornadoes, hundreds of tornadoes, and some of them seemed to be not very strong, but nevertheless damage was quite significant. We look to develop new construction as well as old construction. Old construction, a lack of connecting structure to foundation or connecting roofs to walls—well, I won't get off on that. But then there is new construction, new developments and the issue of soft floor, the issue of additions and maybe last-minute modifications of construction and then we can build a room that can stand internal pressure like that in the process. Then we notice some problems with buildings that seem to be engineered, they seem to have flaws in design. So I think that we need more data resulting, documented data resulting from event investigations. We can learn a lot. There are some designs which are used in the whole country and you can see that under this one extreme condition, you can see the weak spots. So I see similarity in our efforts to reduce damage as we consider hurricanes or tornadoes, but not extreme, but those which occur most quickly.

Mr. MOORE. I don't know that I have as many questions as another comment and if it provokes anything we're going to stop for a minute, but we talk in Congress a lot about values and how we value education, we value our troops, and we value all this and that. What I usually find is we really spend our money where we really believe our values are, not just what we talk about. And certainly life is important. I think all of us acknowledge that, protecting human life from unnecessary loss of life in situations like this. And early warning can certainly aid in reducing the loss of human life in situations where there is a tornado and these weather radios that have come out recently, those—I mean, they cost $20 or something. If people have those and can get the information immediately, they can take shelter if they have shelter in their homes or wherever they are living. And obviously there is an education component to all this and many people in the population now understand what they need to do to protect themselves and that is really cost effective that measures can be taken to protect life.

Beyond that, I think we have discussed here today that there are some things in construction, new construction and retrofitting, that we can do that will fortify and strengthen homes or building structures. That again is going to protect life and property.

And it is sort of frustrating here because we know what needs to be done and I think we just kind of need to make this happen, legislation or something similar to this in Congress that will get the study done to gather the data that needs to be provided to the insurance industry to give some incentives back to people and maybe, you know, the Congress can hear and our colleagues, we can talk about other things that we can do as far as incentives. But it does come down to, as one of you said, to money in a lot of situations. We just need to say that we value the things we're talking about here today and we're willing to make a commitment, a reasonable commitment, to spend some funds to make sure that these things are protected, life and property, and most of all life.

That is my closing statement. I am not trying to shut this down. I am inviting comments, if other people have comments, or the Congressman as well.

Dr. MEADE. I would re-emphasize need and now different hazards—we deal with a lot of floods and people know that it is more predictable that you are going to get flooded if you live in a flood plain. Nevertheless people continue to live there and we continue to have a lot of development there——

Mr. MOORE. Because you can buy homes cheaper there.

Dr. MEADE. Exactly. There are different opinions and I mean there are lots of other discussion going on in Congress about why those incentives are all messed up, but even still, in a situation where people know about the hazard, even still they don't take steps and there is plenty of technology to solve the problem, but again, they need to be incentivized.

So there is an analogy here certainly that living in certain parts of the country, you know that you are subjected to wind hazards and that you have a reasonable probability of suffering under that, but you need to be incentivized still to take action to solve that problem for yourself.

Mr. SHOFNER. I just would like to add that that is one of the hurdles that insurance companies face in that Texas is unique because it's what I call a triple-threat state.

There's a handful of other states that have the same deals, but in Texas we're exposed to hurricanes, tornadoes, and hail, which a lot of states are not. And so with hurricanes there is a lot of research done as far as being able to determine possibly when our coastline may be hit from a hurricane and what size and what have you, but it is very difficult for insurance companies and actuaries to determine if a tornado were to pop up, where it might be and when the next hailstorm is going to come up so those are the things that I know they are trying to work on.

Mr. MOORE. Well, we've got quite a coastline in Kansas, but fortunately we don't have too many hurricanes.

Mr. NEUGEBAUER. Any other final comments by any of the panelists?

Dr. KIESLING. We'd simply plead for patience because it is a very, very complex problem and certainly building the research infrastructure to address that problem is not a short-term process. For example, we are graduating very few people who are capable of assessing the hazards and the risks in their areas and then come up with the solutions for it. And then it takes a long time to build an academic program to do effective research. I think again the action that you are contemplating can be very, very significant there because an important element in developing programs and in attracting faculty to them and so forth, an important consideration is the prospect of long-term funding. I don't know a person that can go into the research business without some hope that there is going to be a future in that area. So it is going to take a long time and we can best probably address the quality issues in housing through building codes, but that too is a slow process and, as you pointed out, I think we're replacing only about one percent of our housing inventory per year. So the results are not going to be coming quickly, but we must take the first steps and begin to turn it around. I think in terms of curbing the damages, rather than reversing them, because it is a long-term process that is not going to be easy to solve.

Mr. MOORE. Randy, may I have one more minute.

Mr. NEUGEBAUER. Sure.

Mr. MOORE. Mr. Chairman said was that your final statement and I said well, maybe it was, but I would like to just kind of sum up here for myself. I'm certainly not trying to shut this down again. I just want to thank the Congressman here for convening this very, very important hearing. I want to thank our witnesses. All of you have been very good, to my knowledge, about what happens here and what needs to happen in the future. I really mean that sincerely and I appreciate your expertise that you shared with us here today and I appreciate the audience being here. Frankly, it's helpful to have the news media out because the extent that this kind of hearing is covered and the people in this area and around the country understand and know that there are things they can do to protect themselves is going to assist what we are trying to accomplish here. So again, thank you, Mr. Chairman.

Mr. NEUGEBAUER. Well, thank the Congressman from Kansas for coming and his interest in this issue. I would just close by saying that I appreciate all of the witnesses that came and took time out of your business schedules. I feel like we had the "A" panel today to discuss this issue. Obviously, many of you are recognized as being on the forefront of this very important research. I thank the folks in the audience that came and I hope that you found this discussion as interesting as I did. I think from my perspective, and I think I've stated this, is I think we need to move forward with a program and I think Dr. Kiesling summed up one of the important aspects, that it is a sustainable program so that we know how many dollars are going to be available for this kind of research and so if there is not an infrastructure in place, that that infrastructure can be put in place to sustain long-term research in that respect.

I also believe very strongly that we are going to have to bring more private sector involvement into this process because in the final analysis, they are going to have to be the ones that build it and market it to people that are going to utilize it. I think we have to bring our friends in the insurance industry into this because they are—they have a risk, they have a financial interest in this, and I think that they can probably share some insight and help with some of the modeling.

I heard at lunch today, talking about how do we model these events and to determine and to develop an economic model determining whether certain things are really economic or not. One of the things that I think makes this a difficult subject for commercialization is that people are insuring a risk or are spending money to mitigate a risk that may never actually materialize and people are more, in our country, are more into, I am interested in the problem that I have today. When you tell them what the odds are that they are going to experience a tornado or odds are that they are going to experience a hurricane, you know, those odds are pretty low.

And so there are a lot of dynamics here that I think have to be worked out, but I think certainly bringing the private sector to the table and bringing the insurance industry adds some additional information that is needed at this table. I look forward to working on some long-term solutions that make sense for our country and for our region. And so thank you and if there are not any other questions we are adjourned.

[Whereupon, the Committee was adjourned.]

Appendix 1:

ADDITIONAL MATERIAL FOR THE RECORD

WIND ENGINEERING RESEARCH AND OUTREACH PLAN TO REDUCE LOSSES DUE TO WIND HAZARDS

AAWE

American Association for Wind Engineering

www.aawe.org

in collaboration with

ASCE

American Society of Civil Engineers

February 2004

EXECUTIVE SUMMARY

Wind hazards - hurricanes, tornadoes, thunderstorms and associated phenomena - cause an unacceptable level of property losses and human suffering in the United States. The average annual financial loss due to these hazards is $6.3 billion. A single large hurricane could cause losses far in excess of $26.5 billion attributed to Hurricane Andrew in 1992.

As a result of ongoing public and private efforts a number of wind hazards mitigation measures have been developed and put in practice in coastal areas and other regions of the United States. These measures have led to significant reduction in fatalities attributed to wind hazards. However, it has not resulted in reversing the alarming trend of increasing material losses. These damages have been in part attributed to a growing population in coastal areas and other regions vulnerable to wind hazards. It has been postulated that the above demographic trend will continue and that significant coordinated efforts need to be undertaken to reduce property losses and human suffering caused by wind hazards.

The research and outreach plan described in this report represents a clear vision for action designed to address the increasing economic losses due to wind hazards. It is proposed that the delineated efforts be carried out within a framework of a federal program – the National Wind Hazards Reduction Program (NWHRP) – that would provide coordination and support of activities necessary for effective reduction in the affects of wind hazards in the United States. It is postulated that such a program will lead to significant reduction in vulnerability to wind hazards in the United States within the next decade.

The concept of NWHRP builds on lessons learned from the 25-year experience with the National Earthquake Hazards Reduction Program (NEHRP). The presented research and outreach plan is an adaptation of the recently revised action plan developed for NEHRP by earthquake engineering community. It comprises of the following four components:

A. Understanding of Wind Hazards: Development of knowledge on severe winds; quantification of the attendant wind loading on buildings, structures and infrastructure; and mapping of wind hazards.

B. Assessment of Impact of Wind Hazards: Assessment of performance of buildings, structures and infrastructure; development of frameworks and tools for simulation and computational modeling; and development of tools for system level modeling and loss assessment.

C. Reduction of Impact of Wind Hazards: Development of retrofit measures for existing buildings, structures and infrastructure; development of innovative wind-resistant technologies for buildings, structures and infrastructure; and development of land measures and cost effective construction practices consistent with site-specific wind hazards.

D. Enhancement of Community Resilience, Education and Outreach: Enhancement of community resilience to wind hazards; effective transfer to professionals of research findings and technology via outreach efforts developed for each component of the NWHRP; and development of effective educational programs and public outreach activities.

Efforts specified for each of these components consist of research and outreach tasks. The research tasks address the science and engineering as well as societal approaches necessary for better risk management practices desirable to prevent losses caused by wind hazards. The outreach tasks are focused on transfer of the research findings and the developed technology to practice.

In formulation of the NWHRP plan attempts were made to develop a dynamic program that would allow for timely use of outcomes of ongoing (in the United States and elsewhere) related research and outreach efforts addressing mitigation of losses due to wind and other natural hazards. Particular attention was given to activities in the area of earthquake engineering, carried out within and beyond the framework of NEHRP. These activities were carefully examined to avoid duplication of efforts delineated in the scope of work proposed for NWHRP.

Recent revolutionary developments in information technology (including sensors, data collection, transfer, processing and visualization, experimental and computational simulation, high-end computing and networking infrastructure) have a potential to lead to unprecedented breakthroughs in our efforts to reduce property losses and human suffering due to wind hazards. Seizing the above opportunities will require federal investment to upgrade the existing and develop new research and outreach infrastructure and human resources.

Reduction in material losses and human suffering within the next decade will require a coordinated, well planned undertaking. The proposed NWHRP provides a framework for implementation of such an initiative, while the presented research and outreach plan outlines the projected scope of work. Establishment of the program will not be possible without significant support and long-term commitment by federal government. Moreover, a delay in upward adjustment in federal support of wind engineering and disciplines related to wind hazards mitigation will undoubtedly lead to further (and probably accelerated) deterioration in the existing national research and outreach infrastructure and in human resources in these areas. This would further impair this Nation's ability to reduce devastating impacts of wind hazards.

ACKNOWLEDGMENTS

This draft report was prepared by ad hoc Committee on Wind Engineering Research Needs, chaired by Bogusz Bienkiewicz, President of AAWE. Contributions to this report were provided by members of the AAWE Board of Directors and by other individuals.

The American Association for Wind Engineering (AAWE) is a national, nonprofit technical society of engineers, architects, atmospheric scientists, planners, public officials and social scientists. AAWE members include researchers, practicing professionals, educators, government officials, and building code regulators. The objectives of AAWE are: (1) The advancement of science and practice of wind engineering; and (2) The solution of national wind engineering problems through transfer of new knowledge into practice.

Founded in 1852, the American Society of Civil Engineers (ASCE) represents more than 133,000 members of the civil engineering profession worldwide, and is America's oldest national engineering society. ASCE's vision is to position engineers as global leaders building a better quality of life. The Society celebrated its 150th anniversary in 2002. ASCE's mission is to provide essential value to its members, their careers, its partners and the public by developing leadership, advancing technology, advocating lifelong learning, and promoting the profession.

PREFACE

This report was prepared to provide background information and to stimulate a constructive debate on the issue of growing vulnerability to wind hazards in the United States and the need for establishment of a coordinated, federally supported program addressing this problem.

Feedback on the presented wind engineering research and outreach plan and on the proposed national program will be sought from members of AAWE and from wind engineering community in general. Professionals involved in wind-resistant design of buildings and structures, researchers, practitioners, as well as decision and policy makers concerned with wind hazards and their impacts will be invited to provide their input. Communication channels for this exchange will be established and announced on the AAWE website (www.aawe.org).

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1. CHALLENGE OF GROWING VULNERABILITY TO WIND HAZARDS

1.1. Impact of Wind Hazards in the United States

Wind-related events inflict major loss of life and material losses in the United States. Figure 1.1 shows breakdown of costs due to damage by tornadoes and hurricanes compared with costs inflicted by floods and earthquakes.

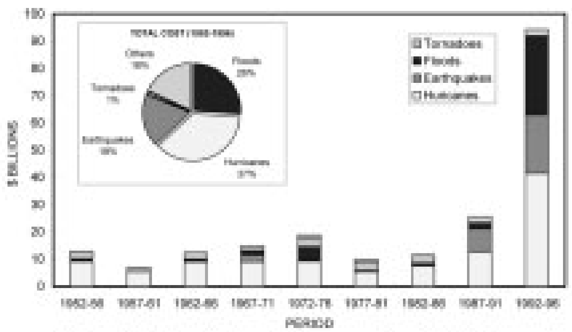

Figure 1.1. Breakdown of Damage Costs, EERI Report[1]

The above costs are presented in more detail in Table 1.1, which is based on the data presented in a report published by RAND[2] (RAND Report).

Table 1.1. Estimated Annualized Losses, by Hazard, RAND Report[2]

Hazard	Estimated Annualized Loss ($ billions)
Hurricanes	5.0
Winter Storms	0.3
Tornadoes	1.0
Total Wind	**6.3**
Floods	3.0
Hail	0.7
Extreme Heat	0.1
Extreme Cold	0.5
Total All Weather	**10.6**
Wildfires	2.0
Earthquakes	4.4

It can be seen that the annualized material losses attributed to wind hazards (inclusive of hurricanes, tornadoes and winter storms) are estimated to be $6.3 billion. They exceed by over 40% and 60%, respectively, losses attributed to earthquakes and floods.

As the authors of the RAND report point out, attempts to provide the hazard loss data (and this applies to any natural hazard) face a number of challenges. They include the variability in occurrence times and magnitude of events resulting in measurable losses, the length of the averaging period used in calculating the annualized losses, and other factors. Calculation of the annualized losses is further complicated by lack of national database of the losses and changing society's vulnerability to wind and other hazards.

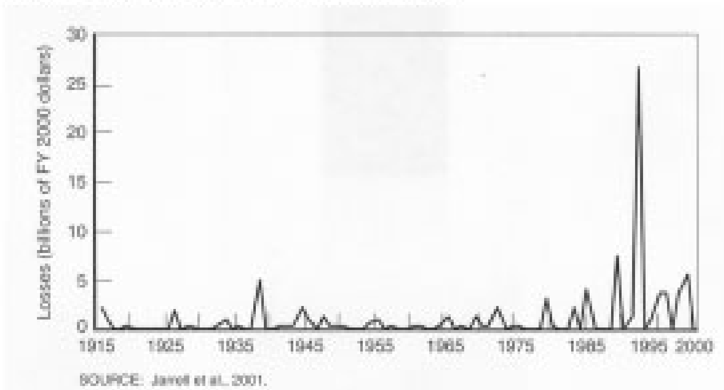

Figure 1.2. U.S. Losses (1915 – 2000), RAND Report[2]

The above wind damage statistics are strongly influenced by hurricane events of large magnitude as depicted in Figure 1.2. For example, in 1992 Hurricane Andrew resulted in $26.5 billion - the highest level of direct and indirect economic losses ever sustained in the United States as the result of a natural hazard event. Analysis of material damage due to landfall of hurricanes in the south-eastern United States over the period 1925 – 1995 showed that the overall damage due to the reported 244 hurricanes and significant tropical storms exceeded $340 billion, with most of the damage attributed to a relatively small number of strong hurricanes - of category 3 and higher on the Saffir-Simpson Scale, Willoughby[3]. A breakdown of the number of hurricanes (and tropical storms) and damage as a function of the hurricane category is presented (after Willoughby) in Figure 1.3.

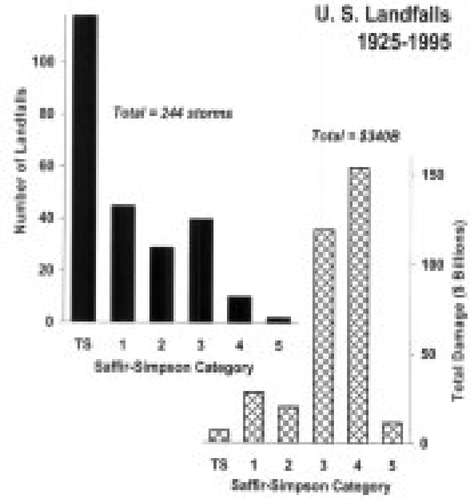

Figure 1.3. Histogram of U.S. Tropical Cyclone/Hurricane Landfall, Willoughby[3]

The highest level of material damage and loss of life has been attributed in the United States to hurricanes, tropical storms, tornadoes and thunderstorms. Devastating effects of landfall of hurricanes have been primarily limited to the Atlantic and Gulf Coast regions and the United States territories. Figure 1.4 provides a representative composite of hurricane tracks.

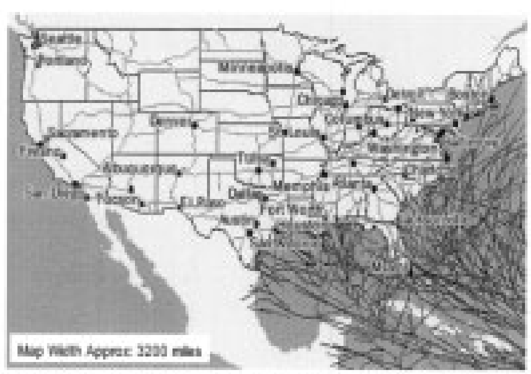

Figure 1.4. Representative Composite of Hurricane Tracks, HazardMaps.gov

Hazards due to tornadoes and thunderstorms are of concern to inhabitants of most of the United States. Territorial reach of tornadoes is illustrated in Figure 1.5, where a distribution of tornadoes (by states) over the 50-year period is depicted.

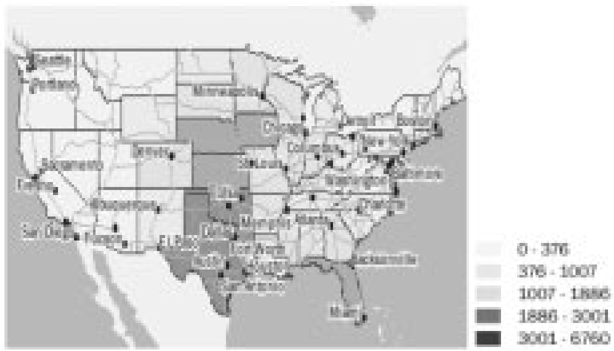

Figure 1.5. Number of Tornadoes by State (1950-2001), HazardMaps.gov

The highest numbers of fatalities and injuries are attributed to tornadoes. Although most of the largest tornadoes occur in the central United States - the tornado alley - tornadoes have been reported both west and east of the alley, Figure 1.5. Tornado touchdowns leading to fatalities and damage in Maryland, Utah and other states are good indications of a wide territorial reach of destructive tornadoes.

Thousands of thunderstorms occur every year all over the United States. Strong winds associated with passage of thunderstorms, at times accompanied by tornadoes, gust fronts and downbursts result in a significant physical damage and human suffering. Local topographic features may lead to amplification of such winds, thus compounding adverse wind effects. Mountain ranges may lead to generation of local strong winds, such as downslope Chinook wind in Rocky Mountains, Santa Anna wind in California and strong winds in northwestern U. S. and in Alaska.

Overall (approximate) measure of the potential wind hazard is represented by wind speed map. Figure 1.6 depicts an example of such a map. Wind provisions of design codes and standards, such as the American Society of Civil Engineers Standard ASCE 7 entitled "Minimum Design Loads for Buildings and Structures"[4] (ASCE 7) provide the recommended design wind speed maps, with disclaimers/restrictions introduced to account for uncertainties/lack of reliable wind speed data.

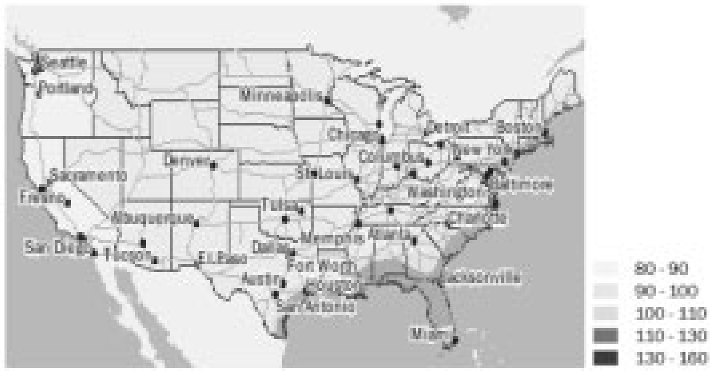

Figure 1.6. Windstorms – Wind Speed 100-Year Exposure (mph), HazardMaps.gov

Storm surge and heavy precipitation accompanying hurricanes both contribute to overall damage and have a potential for causing loss of life and a multitude of long-term undesired consequences. Precipitation associated with thunderstorms and tornadoes may lead to severe flash flooding and its contaminant dangers. Other undesired effects associated with high-wind events include disruptions in transportation during winter storms (due to whiteouts and/or snowdrifts), summer dust storms and hail storms, as well as adverse wind effects on fires.

As a result of ongoing public and private efforts a number of wind hazards mitigation measures have been developed and put in practice in coastal and other regions of the United States. These measures have led to significant reduction in fatalities attributed to wind hazards, mainly due to improved warning times and life protection systems (shelters) in tornado prone regions, and improved forecasting of hurricane landfall and more effective evacuation measures in the Atlantic and Gulf coast areas of the United States, as is illustrated in Figure 1.7. The shaded rectangle in the figure corresponds to the average mortality at mid century 1920-1969, which is scaled by the 314% increase in coastal population during the last half of the century to yield an estimate of 210 deaths annually if society's response to hurricanes had not improved since 1950, Willoughby[3].

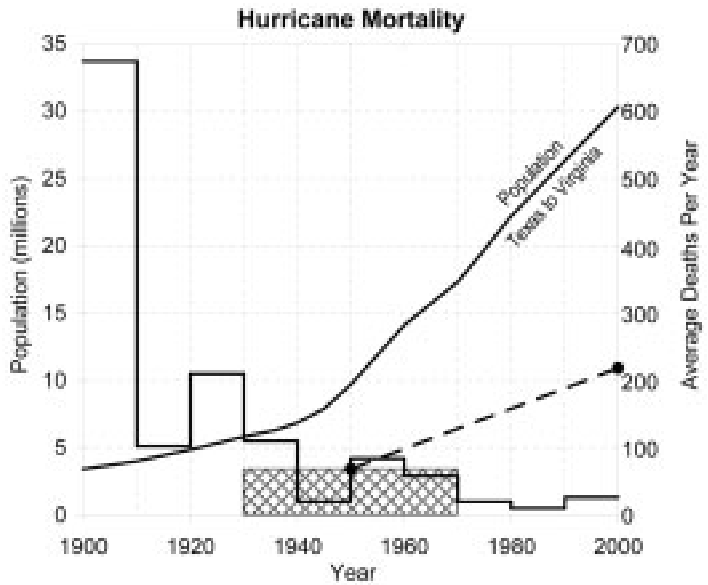

Figure 1.7. Histogram of U.S. Hurricane Mortality and Texas-Virginia Population, Willoughby[3]

Although a marked progress has been achieved in the area of protection of life against wind hazards and the overall trend - continued reduction in fatalities - is very encouraging, an intensified effort is desired to achieve reduction in wind induced property losses.

The data on these losses exhibit the alarming trend - increasing annualized losses - with increasing rate of change in the losses, especially over the past decade.

1.2. Barriers to Reducing Vulnerability to Wind Hazards

In discussion of the material costs of natural disasters, the authors of the RAND Report noted a significant increase (reported by GAO, in 2002) in the disaster relief funds allocated by FEMA: from $7 billion over the period of 1978 – 89 to $39 billion over the next twelve-year period. This trend is shown in more detail in Figure 1.8.

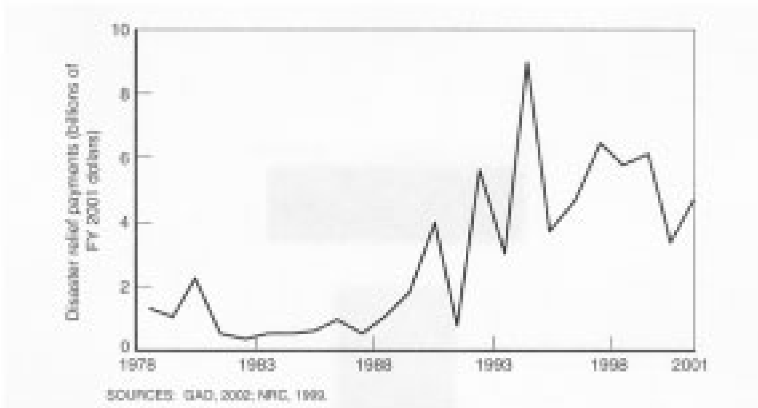

Figure 1.8. Federal Disaster Relief Payments (1978-2001), RAND Report[2]

The authors identified a growing (indeed "exploding") population in areas vulnerable to natural hazards (a relevant case of coastal population is depicted in Figure 1.7) as one of primary reasons for such a dramatic increase in damage and the associated relief funds. A significant portion of these funds has been used to offset material losses due to wind hazards. It has been postulated that the above demographic trend will continue and that significant measures need to be urgently undertaken in order to address the issue of the increasing material losses (and associated relief funds) due to wind hazards.

A number of factors impeding mitigation of damage due to wind and other natural hazards have been identified by natural hazards mitigation community comprising of researchers and practitioners of broad background (ranging from natural and social sciences, engineering, and economics), decision and policy makers, and others. The domain of their evaluation included research and development, technology transfer and implementation, as well as outreach and education. Some of the impediments to effective mitigation of losses due to natural (including wind) hazards were postulated to be coupled with federal funding policies. The authors of the RAND Report concluded that in a number of programs explicit hazard loss reduction activities received the least R&D funding, while much of the spending supported short-term prediction capabilities of limited potential to long-term loss reduction that could improve the resilience of communities and infrastructure, and ultimately result in substantial reduction of losses. A large disparity between federal R&D funding allocated for different natural hazards also was noted.

As was reported before the Science Committee of the U.S. House of Representatives (testimony by Dr. McCabe, during hearing on October 11, 2001[5]), the average annual overall federal investment in research to mitigate impacts of wind hazards is estimated to be $5-10 million. It is instructive to compare this amount with FY2001 funding allocations for fundamental research by National Science Foundation: Civil & Mechanical Systems: Wind - $2.6 million, Earthquakes - $20.8 million; Atmospheric Sciences: Wind + Flood +Drought - $183.8 million, RAND Report, p. 23. It should be noted that the federal funding in excess of $100 million per annum has been invested over the past two decades to support activities geared towards reduction in earthquake losses, through the National Earthquake Hazards Reduction Program. A comparison of these funding levels with the quoted earlier estimate for the annualized wind hazards losses suggest that a significant increase in federal investment in activities geared towards reduction of losses due to wind hazards is urgently needed, justified, and has considerable potential for short- and long-term payoff.

1.3. Accomplishments to -Date to Reduce Losses Due to Wind Hazards

Despite limited federal funding and the lack of a national program focused on reduction of wind-induced losses, research and development efforts to-date have helped to advance our understanding of wind hazards and their effects on the built environment. One of outcomes of this effort are improved provisions for wind-resistant design. Examples include the ASCE Standard[4], which serves as a key resource document for model building codes. Other accomplishments include:

- Improved characterization of winds;
- Statistical analysis and modeling of historical wind records to develop a design wind speed map;
- Improved descriptions of wind pressures and associated loads on structures;
- Improved evaluations of the performance of building envelopes and load-carrying members;
- Development of devices for low-rise structures to improve the wind resistance;
- Improved knowledge regarding wind-generated debris impacts and mitigation techniques;
- Innovations to improve wind-resistant design of buildings and structures.

However, even with the above developments, our understanding and ability to quantify load and resistance characteristics for use in cost effective wind-resistant design and construction practices is far from complete.

1.4. Wind Engineering/Wind Hazards Research Needs

A list of wind engineering research areas identified as critical for reduction of wind-induced loses, provided in the report published by American Association for Wind Engineering[6] (AAWE Report), included:

- Collection of wind speed data using robust instrumentation and state-of the art technology to map detailed structure of the wind, topographic effects, and long-term climate effects;

- Simulation of hurricanes and their wind fields and other extreme wind effects for statistical analysis of wind, wind loads, and wind-induced response of structures and their components;

- Modeling of wind-structure interaction, including effects of integral wind loads on structural systems, components and cladding, effectiveness of retrofitting schemes, effects of structural fatigue and impact by wind-generated missiles, design of cost effective tornado shelters and shelters for hurricane zones to minimize evacuation;

- Study of internal load paths, performance of structural systems, and effectiveness of connections between structural components;

- Field monitoring of structures in natural environment and large-scale tests in simulated loading environment;

- Research in debris impact potential in windstorm and development of impact resistant building components;

- Mapping of wind climate in urban areas;

- Health monitoring and structural control studies for mitigation of wind effects;

- Application of effective numerical schemes using computational fluid dynamics to determine the wind environment and wind loading on and response of buildings, structures, transportation systems and other critical components of civil engineering infrastructure, and to mitigate these effects;

- Development of effective techniques for collection and rapid archiving and dissemination of data acquired during post-disaster investigations;
- Development of cost-effective retrofit techniques to enhance wind resistance of existing structures; and
- Development and application of reliable techniques for cost-benefit analysis of wind hazards mitigation measures and other socio-economic evaluations.

2. OPPORTUNITIES AND BENEFITS OF REDUCTION IN VULNERABILITY TO WIND HAZARDS

2.1. Opportunities to Reduce Vulnerability to Wind Hazards

The existing R&D infrastructure and expertise in wind engineering and other disciplines pertinent to mitigation of wind hazards, recent advances in information technology as well as lessons learned from programs focused on mitigation of other natural hazards, especially earthquakes, form the basis that provides unique opportunities to enhance out efforts to reduce vulnerabilities to wind hazards.

The existing research infrastructure includes laboratory and field facilities used to investigate wind characteristics and wind effects on buildings and structures and their components. The main components of the laboratory infrastructure are long-test-section wind tunnels that allow for realistic modeling of boundary-layer winds and other flow modeling facilities that have been employed in exploratory modeling of other wind phenomena, including tornadoes, hurricanes and downburst outflows. Academic institutions in the United States involved in laboratory modeling of wind effects include: Colorado State University, Texas Tech University, Clemson University, Iowa State University, Louisiana State University and University of Notre Dame.

Over the years, extensive wind engineering field studies focused on wind effects on low-rise buildings and wind hazards mitigation have been carried out by researchers at Texas Tech University, at two sites in Lubbock, TX. A field site to carry out wind engineering investigations primarily focused on manufactured homes was established (and jointly operated by the DOE's Idaho Environmental Engineering Laboratory and University of Wyoming) 30 miles west of Laramie, WY.

Several universities have established programs to collect high fidelity hurricane wind field information near ground, and wind loading on building envelope and building performance during strong wind events. A number of houses at various locations along Atlantic and Gulf coasts have been instrumented or outfitted with wiring and brackets for easy installation of instrumentation. These efforts have been carried out by researchers from Clemson University, University of Florida at Gainesville and University of Illinois at Urbana-Champagn. Several wind engineering research groups (Texas Tech University, Clemson University and University of Florida at Gainesville) use mobile towers (typically 30 feet in height) strategically positioned on an expected path of hurricanes or other high-wind events. These instrumented towers are equipped with back-up power supply and they are capable of withstanding wind speeds up to 200 mph. Recent upgrades of the towers included use of wireless phone communication (successfully deployed for the first time during landfall of Hurricane Isabel in 2003) to transmit the acquired data to a central database in near-real time.

Another example of an innovative application of the emerging sensors, data acquisition and transmission technology is a recent study coordinated by researchers from University of Notre Dame who have been supplementing traditional monitoring devices in measurement of wind-induced response of tall buildings using the Global Positioning System (GPS).

The above cases are only a representative sample of applications of new technologies incoroporated in current R&D focused on mitigation of wind hazards. The revolutionary role of information technology (IT) and unmatched opportunities resulting from its application in efforts geared to reduce vulnerability to natural disasters were discussed in RAND Report. Specific applications of IT in monitoring and simulating seismic hazards and structural response due to earthquakes, as well as in remote data acquisition and interpretation coupled with rapid communication and visualization to aid broad range of stakeholders (ranging from R&D through decision-making and emergency personnel) were discussed in EERI Report[1]. The described applications (of IT) appear to have a tremendous potential to aid tasks to reduce vulnerability to wind hazards and to coordinate local and regional planning to prevent/minimize wind-induced losses.

2.2. Benefits of Coordinated Wind Hazards Mitigation Research

Reducing wind hazards risk is a long-term commitment that builds on past experience and advances in our understanding of wind, wind-induced loading and response of structures, impact of wind-generated debris, and effects of other natural phenomena associated with strong winds (for example surge, hail). Advances in quantifying the physical nature of strong winds, coupled with continuing improvements in engineering methods, will result in significantly increased wind hazard safety, as structures existing in critical wind zones are retrofitted, and new and replacement structures and infrastructure systems are constructed. Research on wind hazards can significantly reduce economic losses resulting from future strong-wind events. Whereas several success stories can be cited, there is a pressing need to continue such research in the future, and at an increased rate.

Because our Nation's livelihood is highly dependent on business activity, a future wind event, even one with only a moderate damage potential, can result in significant economic loss. In an extreme case, the recurrence of a hurricane with the magnitude of hurricane Andrew, with landfall passage over a metropolitan area (such as Miami, Florida) would be devastating. Total loss associated with such event is estimated to exceed $30 billion, with a significant portion of this loss attributable to interruptions in business operations. The tragic events of 9/11 in New York City underscore the severity of economic impact of a major disruption in urban infrastructure and interruptions in business activities.

If relevant and timely research coupled with effective technology transfer can reduce the economic loss from a single future strong-wind event by even a very-conservative 10%, the payoff on the investment will be in the billions of dollars.

3. PROPOSAL FOR ESTABLISHMENT OF NATIONAL WIND HAZARDS REDUCTION PROGRAM (NWHRP)

3.1. Main Components and Areas of Activity

In context of arguments put forth in this presentation and findings advanced elsewhere (RAND Report[2], AAWE Reports[1,6], NRC Report[7], NIST Report[8]), and in view of the current and anticipated future unacceptably high level of wind damage it should be apparent that effective countermeasures are urgently needed and can be developed to stem and reverse these undesirable trends. Evidence has been also presented to support a proposition that an integrated and coordinated long-term effort with well defined, achievable and measurable goals in R&D, education and outreach will be necessary to significantly reduce societal vulnerability to wind hazards with 10–20 year time horizon. Such a goal could be accomplished through establishment of the National Wind Hazards Reduction Program (NWHRP). The establishment of such a program was proposed in the past by Jones et al.[9] and others (NRC Report[7], NIST Report[8]).

Table 3.1. Main Components and Major Areas of Activities of the NWHRP

Component A **Understanding of Wind Hazards**	**Component B** **Assessment of Impact of Wind Hazards**	**Component C** **Reduction of Impact of Wind Hazards**		**Component D** **Enhancement of Community Resilience, Education, & Outreach**
Enhanced Knowledge and Data on Severe Winds	Performance of Buildings, Structures and Critical Infrastructure Using Data Collection, Experimentation & Synthesis	Retrofit Measures for Existing Buildings, Structures & Infrastructure	Cost Effectiveness of Loss Mitigation	Community Resilience to Wind Hazards
Improved Understanding & Quantification of Wind Loading on Buildings and Structures	Tools for Component and Structure-Level Simulation & Computational Modeling	Innovative Technologies for New Buildings, Structures & Infrastructure	Financial Instruments for Risk Transfer	Cross-Area Outreach & Education
Mapping of Wind Hazards	Tools for System-Level/Loss Assessment	Land Use & Cost Effective Construction	Emergency Response & Recovery	Education & Public Outreach

The concept and implementation of the NWHRP should be built on lessons learned from the 25-year experience with the National Earthquake Hazards Reduction Program (NEHRP). The starting point in this process could be the revised concept of the NEHRP described in the EERI Report[1]. Adaptation of this model for the NWHRP is summarized in Table 3.1, where main components and major areas of each component of the program are presented.

As shown in Table 3.1, the program comprises of the following four components:

A. Understanding of Wind Hazards: Development of knowledge on severe winds; quantification of the attendant wind loading on buildings, structures and infrastructure; and mapping of wind hazards.

B. Assessment of Impact of Wind Hazards: Assessment of performance of buildings, structures and infrastructure; development of frameworks and tools for simulation and computational modeling; and development of tools for system level modeling and loss assessment.

C. Reduction of Impact of Wind Hazards: Development of retrofit measures for existing buildings, structures and infrastructure; development of innovative wind-resistant technologies for buildings, structures and infrastructure; and development of land measures and cost effective construction practices consistent with site-specific wind hazards.

D. Enhancement of Community Resilience, Education and Outreach: Enhancement of community resilience to wind hazards; effective transfer to professionals of research findings and technology via outreach efforts developed for each component of NWHRP; and development of effective educational programs and public outreach activities.

Efforts specified for each component consist of research and outreach tasks. The research tasks address the science and engineering as well as societal approaches necessary for better risk management practices desirable to prevent losses caused by wind hazards. The outreach tasks are focused on transfer of the research findings and the developed technology to practice.

Implementation of the above concept is based on a sequential progression from Component A through Component D. Due to cross-component nature, many outreach tasks of Component D are planned to be activated at appropriate phases of progress in research tasks of all the components of the program.

In formulation of the NWHRP plan attempts were made to develop a dynamic program that would allow for timely use of outcomes of ongoing (in the United

States and elsewhere) related research and outreach efforts addressing mitigation of losses due to wind and other natural hazards. A particular attention was given to activities in the area of earthquake engineering, carried out within and beyond the framework of NEHRP. These activities were carefully examined to avoid duplication of effort delineated in the scope of work proposed for NWHRP.

3.2. Potential Impact of Information Technology

Recent developments in information technology (sensors; data collection, transfer, processing and visualization; experimental and computational simulation; high-end computing; and adaptive networking) have a potential to lead to unprecedented breakthroughs in our efforts to reduce property losses and human suffering due to wind hazards. These advances in information technology (IT) have already significantly influenced activities addressing impacts of natural hazards. Two representative examples of relevance to NWHRP are discussed below.

The first example is the Network for Earthquake Engineering Simulation (NEES). Significant federal investment has been authorized by Congress for the development of NEES - $82 million over the 2002-2004 period. This funding was allocated for construction/enhancement of engineering laboratories at fifteen universities and development of an advanced networked and grid-enabled experimental, data, and computational infrastructure. This resource makes possible implementation of a concept of "colaboratory" which enables researchers to remotely interact with each other and with their simulation and computational work via "telepresence" tools. Application of these concepts and infrastructure appears to have a great potential for breakthroughs in wind hazards research and outreach. Modest investment to upgrade wind engineering experimental (laboratory/field) and computational infrastructure, coupled with shared use of the NEES networking capabilities would allow for an efficient exploratory application of these technologies in activities of NWHRP.

The second example is utilization of low-cost, small-size (3 ft x 3 ft) networked radars that can be placed on existing cellular towers. These short-range sensors can provide information on low-level winds and other properties of the atmospheric surface layer. They are currently being developed by one of the Engineering Research Centers (supported by NSF) and they are scheduled to be tested in mid 2005, in a networked configuration covering approximately 20 percent of the State of Oklahoma. This technology appears to have potential for application in mapping of wind hazards and in other activities of the NWHRP.

4. UNDERSTANDING OF WIND HAZARDS (COMPONENT A)

The first step towards protecting society from losses due to wind hazards is a significant improvement in our understanding of wind hazards in the United States. Areas identified to be critical for accomplishing this goal are listed in Tables 4.1 and 4.2. They are divided into two groups: Research Tasks (Table 4.1) and Outreach Tasks (Table 4.2). The research tasks delineate areas broadly defined for Component A in Table 3.1., while the tasks in Table 4.2 refer to the related outreach effort of this component and cross-component/area outreach listed in Table 3.1 under the Component D heading.

4.1. Research Tasks

The tasks listed in Table 4.1 address research that would improve our understanding of severe winds (including hurricanes, tornadoes, thunderstorms, and other strong winds phenomena) and wind-induced loading on buildings and structures. They are designed to take advantage from rapid advances in sensors, data acquisition, processing and sharing, as well as simulation and visualization.

Table 4.1. Research Tasks of Component A – Understanding of Wind Hazards

AR1. Enhanced Knowledge and Data on Severe Winds

a. Improve characterization and archival of properties of severe winds (hurricanes, thunderstorms, tornadoes, downslope winds).
b. Enhance/develop instrumentation and data transfer/processing infrastructure for acquisition of severe wind/wind loading data and data archival.
c. Develop simulation techniques (analytical, physical, numerical) for modeling severe winds, for studies of wind hazards impact.
d. Gain knowledge on wind-borne debris and impact on structures.
e. Synthesize/improve knowledge on other natural phenomena contributing to wind hazards impact (water surge, flooding).

AR2. Understanding and Quantification of Wind Loading

a. Develop field/laboratory database and knowledge-based system/model for wind loading on buildings and structures exposed to different types of wind.
b. Develop infrastructure/simulation techniques (analytical, physical, numerical) for modeling of loading on buildings and structures induced by severe winds.
c. Develop demonstration/benchmark studies employing the developed tools.

AR3. Mapping of Wind Hazards

a. Develop techniques for modeling orographic, topographic and urban effects on wind hazards.
b. Develop mapping of wind hazards in critical regions.

Tasks AR1 and AR2 reflect the progression from the development of the necessary field and laboratory infrastructure, acquisition of knowledge through field and laboratory experimentation, through the development and application of simulation techniques, and synthesis of the developed knowledge on severe winds and wind-induced loading. This effort also includes development and application of techniques for mapping of wind hazards, Task AR3.

4.2. Outreach Tasks

The outreach tasks listed in Table 4.2 are geared towards rapid application and dissemination of findings of the research tasks discussed above. As can be seen, they include transfer of the developed knowledge and tools into codes, standards and guidelines and dissemination of these innovations to practicing professionals. These efforts cover all the areas addressed by the research tasks: the severe winds and wind-induced loading, (Task AO1), and mapping of wind hazards, Task AO2.

Table 4.2. Outreach Tasks of Component A – Understanding of Wind Hazards

AO1. Enhanced Knowledge and Data on Severe Winds and Wind Loading

a. Incorporate the developed knowledge/techniques/models into codes & guidelines.
b. Disseminate the developed codes & guidelines and knowledge/techniques & models to practicing professionals.

AO2. Mapping of Wind Hazards

a. Disseminate wind hazards characterization/zonation of urban (suburban) regions.
b. Develop/improve surge/flood mapping and warning.

5. ASSESSMENT OF IMPACT OF WIND HAZARDS (COMPONENT B)

The research and outreach tasks of this component are summarized respectively in Tables 5.1 and 5.2. The research tasks (Table 5.1) delineate the effort areas listed in Table 3.1 for Component B. The outreach tasks (Table 5.2) are arranged in a manner similar to that implemented for component A, Table 4.2.

5.1. Research Tasks

As shown in Table 5.1, three research initiatives, denoted BR1 though BR3, are proposed to address shortcomings of our understanding of impact of wind hazards on built environment.

Table 5.1. Research Tasks of Comp. B - Assessment of Impact of Wind Hazards

BR1. Wind Resistance of Buildings, Structures and Critical Infrastructure Using Data Collection, Experimentation & Synthesis

a. Improve knowledge on behavior of structural and nonstructural components through field monitoring and laboratory studies.
b. Improve understanding of wind load paths and response of full structural systems through field monitoring and physical modeling of subsystems and complete systems.
c. Synthesize information for the development and validation of structure-level tools.
d. Improve understanding of wind-borne debris impact and protective measures.

BR2. Tools for Component and Structure-Level Simulation & Computational Modeling of Wind Effects

a. Develop models for structural and non-structural components.
b. Develop models of subassemblies/substructures, and global systems.
c. Develop high-end/grid-based computational methods for simulating wind loading and wind-induced structural response.
d. Institute collaborative development of software tools and protocols for the wind/structural engineering community.
e. Develop large-scale databases and visualization tools for simulation of wind effects.

BR3. Tools for System-Level/Loss Assessment of Wind Hazards

a. Perform validation studies to calibrate the existing loss estimation models, incorporating physical and societal impact of losses for wind hazards and related phenomena.
b. Improve damage and fragility models for buildings and structures.
c. Improve indirect loss estimation models for wind hazards.

The experimental database will be established, based on data acquired during hurricanes (and other strong-wind events), controlled field experiments and laboratory investigations. The obtained knowledge will be synthesized and utilized in development and validation of tools for component and structure-level simulation and computational modeling of wind effects, and for system-level/loss assessment of wind hazards.

5.2. Outreach Tasks

The outreach tasks shown in Table 5.2 are a direct extension of each of the research efforts delineated in Table 5.1.

Table 5.2. Outreach Tasks of Comp. B – Assessment of Impact of Wind Hazards

BO1. Wind Resistance of Buildings, Structures and Critical Infrastructure Using Data Collection, Experimentation & Synthesis

a. Develop research plan for needed experiments on structural and nonstructural and structure-level components to address shortcomings of existing techniques for prediction of wind resistance of buildings and structures.
b. Develop implementation strategy for deployment of sensors in buildings and structures; identify incentives for deploying sensors through policy instruments.
c. Develop consensus guidelines for deployment of sensors and their use in operation of buildings and constructed facilities, including interfaces with emergency responders.

BO2. Tools for Component and Structure-Level Simulation & Computational Modeling of Wind Effects

a. Create new models for representing behavior of structural and nonstructural components for use in computer software for simulation of wind resistance of buildings and structures.
b. Form a consensus-based wind/structural engineering organization for the development and dissemination of standards for wind loading simulation software.
c. Develop strategy to utilize national high-end computational resources for problems of wind engineering; include practicing engineers in participation in this task and in dissemination of the developed new simulation technologies.

BO3. Tools for System-Level/Loss Assessment of Wind Hazards

a. Develop next-generation loss estimation methods utilizing new simulation technologies, databases and high-end computing and visualization tools.
b. Develop outreach plan for improving building inventory of communities.
c. Work with communities in creating databases and specific modules for loss estimation from wind hazards and related phenomena.

6. REDUCTION OF IMPACT OF WIND HAZARDS (COMPONENT C)

6.1. Research Tasks

The research tasks proposed for this component are summarized in Table 6.1. They are divided into six categories that range from assessment of technologies

Table 6.1. Research Tasks of Comp. C – Reduction of Impact of Wind Hazards

CR1. Retrofit of Structural & Nonstructural Systems of Existing Buildings &Structures

a. Determine strength and life cycle characteristics of new and existing materials and component/subsystems.
b. Perform in-situ characterization of existing materials, components and subsystems.
c. Develop cost-effective strategies for retrofitting existing inventory of buildings, structures and infrastructure.

CR2. Innovative Technologies for New Buildings, Structures & Infrastructure

a. Develop cost effective innovative technologies for new buildings, structures and infrastructure.

CR3. Land Use Measures and Cost Effective Construction Practices

a. Develop land use measures and cost effective construction practices addressing mapped wind hazards.

CR4. Cost Effectiveness of Wind Loss Mitigation

a. Define performance measures.
b. Improve loss estimation models, including indirect losses.
c. Develop demonstration studies/cases.
d. Demonstrate application of developed tools in post-event setting.

CR5. Financial Instruments to Transfer Risks

a. Collect and disseminate insured wind loss data.
b. Assess effectiveness of risk transfer methods.
c. Perform cost-benefit analysis targeting various stakeholders.
d. Analyze insurance industry issues (e.g. mitigation versus insurance).

CR6. Existing and Emerging Technologies for Emergency Response and Recovery

a. Develop tools for real-time monitoring of wind hazards (hurricane landfall)
b. Develop real-time loss estimation tools for wind hazards.
c. Develop remote-sensing technologies for wind damage assessment.
d. Adapt/develop advanced decision support systems for wind hazards response and recovery.

for retrofit of structures through the development of techniques for emergency response and recovery. The research on retrofit includes both existing (Task CR1) and new buildings and structures (Task CR2). Cost effectiveness of construction practices and loss mitigation measures are addressed by Tasks CR3 and CR4, respectively, while transfer of risks is the subject of Task CR5. Task CR6 is focused on technologies for emergency response and recovery.

6.2. Outreach Tasks

The outreach tasks cover activities related to development of design codes and guidelines, demonstration projects, products for performance-based wind resistant design, development of demonstration projects, databases, studies of benefits/efficacy of transfer of wind hazards risks, and integration of loss estimation and decision support tools and methodology developed for other purposes into networked environment to assist wind disaster management. These tasks complement the research tasks proposed for this component of the NWHRP.

Table 6.2. Outreach Tasks of Comp. C – Reduction of Impact of Wind Hazards

CO1. Codes, Guidelines and Demonstration Projects

a. Develop guidelines, manuals of practice, and model codes for wind-resistant design of buildings, structures, and infrastructure.
b. Develop products for the implementation of performance-based wind resistant design.
c. Conduct demonstration projects involving researchers, practitioners, owners, and other stakeholders in the assessment and mitigation of wind hazards to buildings and other constructed facilities.
d. Conduct short courses on new technologies, codes, and guidelines.

CO2. Financial Instruments to Transfer Risks

a. Collect insured loss data after major wind damage event.
b. Develop a comprehensive, publicly accessible database on these events.
c. Perform case studies on the long-term benefits/efficacy of wind hazards risks transfer methods.

CO3. Existing and Emerging Technologies for Emergency Response and Recovery

a. Integrate loss estimation tools with real-time information on wind hazard events.
b. Develop and apply methodologies to update post-event loss estimates with post-event data from field and aerial surveys.
c. Develop decision tools that can incorporate data from disparate data sources and update decision making process.
d. Incorporate data and networking research being performed for other purposes into wind disaster management.

7. ENHANCEMENT OF COMMUNITY RESILIENCE, EDUCATION AND OUTREACH (COMPONENT D)

7.1. Community Resilience to Wind Hazards

Community resilience to wind (and other) hazards is affected by a number of factors. Loss reduction strategies focusing on specific structures and facilities are only a part of process geared towards enhancing such resilience. Strengthening policy making for wind hazards safety requires a better understanding of the social end economic implications of catastrophic wind events. Development of methodologies and assessment of community vulnerability to wind hazards, investigation of societal impacts, decision making, and perception of wind hazards risks are the subjects of the proposed research tasks listed in Table 7.1. Included in the table is a set of related outreach tasks that range from development of decision tools and regulatory processes through methodologies and demonstrations for targeted audience.

Table 7.1. Tasks of Community Resilience to Wind Hazards (DC)

DCR. Research Tasks

a. Develop methodologies and assessment of effectiveness in reducing vulnerability and enhancing community resilience to wind hazards.
b. Investigate societal impacts of significant wind events, including "lessons learned".
c. Investigate decision making and perception of wind hazards risks.

DCO. Outreach Tasks

a. Provide decision tools for relevant stakeholders, policy makers, state and local government officials, design professionals, and others.
b. Develop process for improving regulatory system.
c. Develop new methodologies and demonstration effort for targeted audience.

Work on the above research and outreach tasks will draw on research findings and outreach experience resulting from other efforts addressing community resilience, including the resilience to earthquakes (through NEHRP and related initiatives) and other natural and man-made hazards.

7.2. Education and Public Outreach

The most immediate needs for education and outreach relate to design professionals, construction industry, and state and local government officials.

These needs are addressed by outreach tasks of the program components A (Table 4.2), B (Table 5.2) and C (Table 6.2). As achievement of reduction in wind losses requires a long-term effort, education of the next generation of professionals (to be engaged in this activity) and general public is desired to ensure success in this endeavor. Initiatives proposed to accomplish this educational/outreach goal are listed in Table 7.2. They include enhancement of curricula, internships and camps for pre-college (K-12) and college students. Items proposed to enhance college-level education include participation in wind damage investigations,

Table 7.2. Tasks of Education and Public Outreach (DEP)

DEP1. Pre-College (K-12)

a. Enhance curriculum in meteorology and wind engineering.
b. Develop programs for early-learning experiences for K-12 students, including summer internships and camps.

DEP2. College – Undergraduate Program

a. Enhance curriculum in engineering meteorology, wind and structural engineering and in architecture.
b. Establish internship programs for junior and senior students.
c. Develop incentive programs for underrepresented groups, women and minorities.

DEP3. College - Graduate Program

a. Increase scholarship and assistantship funds for masters and doctoral programs.
b. Develop programs for participation in wind damage reconnaissance.
c. Develop practice-oriented masters degrees for practicing professionals.
d. Establish incentive programs for underrepresented groups, women, and other minorities.

DEP4. Continuing Education

a. Develop short courses on recent advances in wind engineering, risk management, emergency response and recovery using traditional and innovative (web-based interactive formats) distance-learning technologies.
b. Develop training courses in emerging technologies using web-based interactive mode and other formats.

DEP5. Public Awareness & Outreach

a. Enhance media relations and communication.
b. Provide support for national and international conferences, workshops and major public meetings.
c. Develop infrastructure and tools for information dissemination though helpline, and web-based outreach.
d. Prepare articles for public media.
e. Hold annual public meeting on frontiers in wind engineering.

practice oriented programs, as well as scholarships and incentive programs for underrepresented groups, women and other minorities.

8. BUDGET ESTIMATE FOR NWHRP

The estimated 3-year annual budget for the proposed program is presented in Tables 8.1 through 8.3.

Table 8.1. Annual Budget – Year 1 (RT (OT) = research (outreach) tasks)

ANNUAL BUDGET BREAKDOWN BY TASKS		($M)	RT	OT	TOT
A	**UNDERSTANDING OF WIND HAZARDS**		7.0	0.5	**7.5**
AR1	Enhanced Knowledge on Severe Winds	3.3			
AR2	Understanding and Quantification of Wind Loading	2.8			
AR3	Mapping of Wind Hazards	1.0			
AO1	Enhanced Knowledge on Severe Winds	0.3			
AO2	Mapping of Wind Hazards	0.3			
B	**ASSESSMENT OF IMPACT OF WIND HAZARDS**		6.8	1.7	**8.5**
BR1	Structural Resistance Using Data Collection	3.0			
BR2	Tools for Simulation and Modeling	3.0			
BR3	Tools for System-Level/Wind Loss Assessment	0.8			
BO1	Structural Resistance Using Data Collection	0.2			
BO2	Tools for Simulation and Modeling	0.7			
BO3	Tools for System-Level/Wind Loss Assessment	0.8			
C	**REDUCTION OF IMPACT OF WIND HAZARDS**		6.4	3.0	**9.4**
CR1	Retrofit of Existing Buildings and Structures	2.3			
CR2	Innovative Strategies for New Buildings & Structures	0.5			
CR3	Land Use Measures & Construction Practices	0.3			
CR4	Cost Effectiveness of Wind Loss Mitigation	0.8			
CR5	Financial Instruments to Transfer Risks	0.8			
CR6	Technologies for Emergency Response and Recovery	1.9			
CO1	Codes, Guidelines and Demonstration Projects	1.00			
CO2	Financial Instruments to Transfer Risks	0.88			
CO3	Technologies for Emergency Response and Recovery	1.13			
D	**ENHANCE COMMUNITY RESILIENCE, EDUC. & PUBLIC OUTREACH**				
DC	**COMMUNITY RESILIENCE TO WIND HAZARDS**		0.5	1.0	**1.5**
DCR	Research Tasks	0.50			
DCO	Outreach Tasks	1.00			
DEP	**EDUCATION AND PUBLIC OUTREACH**		0.0	4.6	**4.6**
DEP1	Pre-College (K-12)	0.50			
DEP2	College - Undergraduate Program	1.00			
DEP3	College - Graduate Program	2.00			
DEP4	Continuing Education	0.45			
DEP5	Public Awareness & Outreach	0.60			
	GRAND TOTAL ALL COMPONENTS		20.6	10.8	**31.4**

Table 8.2. Annual Budget – Year 2 (RT (OT) = research (outreach) tasks)

ANNUAL BUDGET BREAKDOWN BY TASKS		($M)	RT	OT	TOT
A	**UNDERSTANDING OF WIND HAZARDS**		14.0	1.0	**15.0**
AR1	Enhanced Knowledge on Severe Winds	6.5			
AR2	Understanding and Quantification of Wind Loading	5.5			
AR3	Mapping of Wind Hazards	2.0			
AO1	Enhanced Knowledge on Severe Winds	0.5			
AO2	Mapping of Wind Hazards	0.5			
B	**ASSESSMENT OF IMPACT OF WIND HAZARDS**		13.5	3.4	**16.9**
BR1	Structural Resistance Using Data Collection	6.0			
BR2	Tools for Simulation and Modeling	6.0			
BR3	Tools for System-Level/Wind Loss Assessment	1.5			
BO1	Structural Resistance Using Data Collection	0.5			
BO2	Tools for Simulation and Modeling	1.3			
BO3	Tools for System-Level/Wind Loss Assessment	1.7			
C	**REDUCTION OF IMPACT OF WIND HAZARDS**		12.8	5.0	**17.8**
CR1	Retrofit of Existing Buildings and Structures	4.5			
CR2	Innovative Strategies for New Buildings & Structures	1.0			
CR3	Land Use Measures & Construction Practices	0.5			
CR4	Cost Effectiveness of Wind Loss Mitigation	1.5			
CR5	Financial Instruments to Transfer Risks	1.5			
CR6	Technologies for Emergency Response and Recovery	3.8			
CO1	Codes, Guidelines and Demonstration Projects	1.00			
CO2	Financial Instruments to Transfer Risks	1.75			
CO3	Technologies for Emergency Response and Recovery	2.25			
D	**ENHANCE COMMUNITY RESILIENCE, EDUC. & PUBLIC OUTREACH**				
DC	**COMMUNITY RESILIENCE TO WIND HAZARDS**		1.0	2.0	**3.0**
DCR	Research Tasks	1.00			
DCO	Outreach Tasks	2.00			
DEP	**EDUCATION AND PUBLIC OUTREACH**		0.0	9.1	**9.1**
DEP1	Pre-College (K-12)	1.00			
DEP2	College - Undergraduate Program	2.00			
DEP3	College - Graduate Program	4.00			
DEP4	Continuing Education	0.90			
DEP5	Public Awareness & Outreach	1.20			
	GRAND TOTAL ALL COMPONENTS		41.3	20.5	**61.8**

Table 8.3. Annual Budget – Year 3 (RT (OT) = research (outreach) tasks)

ANNUAL BUDGET BREAKDOWN BY TASKS		($M)	RT	OT	TOT
A	**UNDERSTANDING OF WIND HAZARDS**		21.0	1.5	**22.5**
AR1	Enhanced Knowledge on Severe Winds	9.8			
AR2	Understanding and Quantification of Wind Loading	8.3			
AR3	Mapping of Wind Hazards	3.0			
AO1	Enhanced Knowledge on Severe Winds	0.8			
AO2	Mapping of Wind Hazards	0.8			
B	**ASSESSMENT OF IMPACT OF WIND HAZARDS**		20.3	5.1	**25.4**
BR1	Structural Resistance Using Data Collection	9.0			
BR2	Tools for Simulation and Modeling	9.0			
BR3	Tools for System-Level/Wind Loss Assessment	2.3			
BO1	Structural Resistance Using Data Collection	0.7			
BO2	Tools for Simulation and Modeling	2.0			
BO3	Tools for System-Level/Wind Loss Assessment	2.5			
C	**REDUCTION OF IMPACT OF WIND HAZARDS**		19.1	7.0	**26.1**
CR1	Retrofit of Existing Buildings and Structures	6.8			
CR2	Innovative Strategies for New Buildings & Structures	1.5			
CR3	Land Use Measures & Construction Practices	0.8			
CR4	Cost Effectiveness of Wind Loss Mitigation	2.3			
CR5	Financial Instruments to Transfer Risks	2.3			
CR6	Technologies for Emergency Response and Recovery	5.6			
CO1	Codes, Guidelines and Demonstration Projects	1.00			
CO2	Financial Instruments to Transfer Risks	2.63			
CO3	Technologies for Emergency Response and Recovery	3.38			
D	**ENHANCE COMMUNITY RESILIENCE, EDUC. & PUBLIC OUTREACH**				
DC	**COMMUNITY RESILIENCE TO WIND HAZARDS**		1.5	3.0	**4.5**
DCR	Research Tasks	1.50			
DCO	Outreach Tasks	3.00			
DEP	**EDUCATION AND PUBLIC OUTREACH**		0.0	13.7	**13.7**
DEP1	Pre-College (K-12)	1.50			
DEP2	College - Undergraduate Program	3.00			
DEP3	College - Graduate Program	6.00			
DEP4	Continuing Education	1.35			
DEP5	Public Awareness & Outreach	1.80			
	GRAND TOTAL ALL COMPONENTS		61.9	30.3	**92.1**

A summary of the average annual budget is presented in Table 8.4 and in Figure 8.1. A detailed distribution of this budget is provided in Appendix.

Table 8.4. Summary of Average Annual Budget

	PROGRAM COMPONENT	($M)	($M)	(%)
A	**UNDERSTANDING OF WIND HAZARDS**		**15.0**	
	Research Tasks	14.0		
	Outreach Tasks	1.0		
B	**ASSESSMENT OF IMPACT OF WIND HAZARDS**		**16.9**	
	Research Tasks	13.5		
	Outreach Tasks	3.4		
C	**REDUCTION OF IMPACT OF WIND HAZARDS**		**17.8**	
	Research Tasks	12.8		
	Outreach Tasks	5.0		
D	**ENHANCE COMMUNITY RESILIENCE, EDUC. & PUB. OUTREACH.**			
	COMMUNITY RESILIENCE TO WIND HAZARDS		**3.0**	
	Research Tasks	1.0		
	Outreach Tasks	2.0		
	EDUCATION AND PUBLIC OUTREACH	9.1	**9.1**	
	Grand Subtotal - Research Tasks		**41.3**	**67**
	Grand Subtotal – Outreach & Education Tasks		**20.5**	**33**
	GRAND TOTAL		**61.8**	

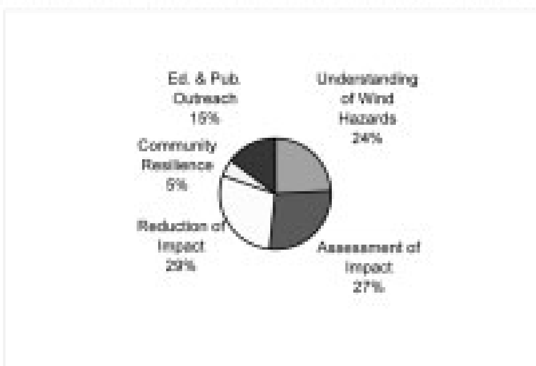

Figure 8.1. Average Annual Budget Distribution by Activity

It should be noted that the average annual budget of $61.8M is approximately equal to 1% of the annualized material losses in the United States.

A summary of budget distribution by activity, for a 3-year period is presented in Table 8.5.

Table 8.5.Summary of 3-Year Budget Projection

	PROGRAM COMPONENT	YR 1	YR 2	YR 3
A	UNDERSTANDING OF WIND HAZARDS	7.5	15.0	22.5
B	ASSESSMENT OF IMPACT OF WIND HAZARDS	8.5	16.9	25.4
C	REDUCTION OF IMPACT OF WIND HAZARDS	9.4	17.8	26.1
D	ENHANCE COMMUNITY RESILIENCE, EDUC. & PUB. OUTR.			
	COMMUNITY RESILIENCE TO WIND HAZARDS	1.5	3.0	4.5
	EDUCATION AND PUBLIC OUTREACH	4.6	9.1	13.7
	TOTAL	**31.4**	**61.8**	**92.1**

9. CONCLUDING REMARKS

This report discusses the challenge of growing vulnerability to wind hazards in the United States and it presents an overview of opportunities as well as benefits of reduction in this vulnerability. Establishment of a federal program – the National Wind Hazards Reduction Program (NWHRP) – is proposed to address this pressing problem. The concept of NWHRP, as well as research and outreach plan, are presented. The proposed program builds on lessons learned from the 25-year experience with the National Earthquake Hazards Mitigation Program (NEHRP). Adaptation of the recently developed (by earthquake engineering community) revised concept and action plan for NEHRP is proposed for NWHRP. A detailed breakdown of the identified NWHRP components and activities is presented.

The long-term goal of the NWHRP is to prevent catastrophic losses from wind hazards. The proposed plan outlines specific tasks for research and outreach activities, identified to be necessary to achieve this goal. The plan calls for rapid implementation of research findings and technology transfer to practitioners and (in many instances) to general public. To accomplish this goal, specific outreach tasks are identified for each component of the program. Many of the delineated outreach efforts are direct extensions of the research tasks proposed for a given component of the NWHRP.

In formulation of the NWHRP attempts were made to develop a dynamic program that would allow for timely use of outcomes of ongoing (in the United States and elsewhere) related research and outreach efforts addressing mitigation of losses due to wind and other natural hazards. A particular attention was given to activities in the area of earthquake engineering, carried out within and beyond the framework of the NEHRP. These activities were carefully examined to avoid duplication of effort delineated in the scope of work proposed for the NWHRP.

Over the past three decades invaluable wind engineering and wind hazards mitigation resources (research and outreach infrastructure and know-how) have been developed in the United States. Despite limited federal funding and lack of a national program focused on reduction of wind-induced losses, research and development efforts to-date have helped on a piecemeal basis to advance our understanding of wind hazards and their effects on the built environment. During this time, significant reduction in fatalities attributed to wind hazards was reported. However, this effort did not lead to reduction in material losses. On the contrary, property losses have significantly increased.

As discussed in this report (and elsewhere, e.g. RAND Report) a significant coordinated federal effort will be required to reverse this undesirable trend. The research and outreach plan described in this report represents a comprehensive approach to this problem. Implementation of this plan through activities of the proposed NWHRP promises to have a very high level of success in achieving significant reduction in wind hazards impacts within the next decade.

Recent revolutionary developments in information technology (including sensors, data collection, transfer, processing and visualization, experimental and computational simulation, high-end computing and networking infrastructure) have a potential to lead to unprecedented breakthroughs in our efforts to reduce property losses and human suffering due to wind hazards. Sizing the above opportunities will require federal investment to upgrade the existing and develop new research and outreach infrastructure and human resources.

Reduction in material losses and human suffering within the next decade will not be possible without a significant and long-term federal commitment. Moreover, delay in adjustment in federal support in these areas will undoubtedly lead to further (and probably accelerated) deterioration in currently existing national research and outreach infrastructure and in human resources in wind engineering, wind hazards mitigation and in related disciplines.

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APPENDIX: BREAKDOWN OF AVERAGE ANNUAL BUDGET

	PROGRAM COMPONENTS AND TASKS	($M)	($M)
A	**UNDERSTANDING OF WIND HAZARDS**		
AR1	**Enhanced Knowledge on Severe Winds**		6.5
a	Characterization and archival of properties	2	
b	Instrumentation and data transfer/processing	3	
c	Develop simulation techniques	0.5	
d	Knowledge on wind-borne debris	0.5	
e	Knowledge on related natural phenomena	0.5	
AR2	**Understanding and Quantification of Wind Loading**		5.5
a	Field/laboratory database & knowledge-based model	2	
b	Develop infrastructure/simulation techniques for loading	3	
c	Develop demonstration/benchmark studies	0.5	
AR3	**Mapping of Wind Hazards**		2
a	Techniques for modeling orographic, topographic effects	1	
b	Develop mapping of wind hazards	1	
AO1	**Enhanced Knowledge on Severe Winds**		0.5
a	Upgrade codes and guidelines	0.25	
b	Disseminate developed codes, guidelines and knowledge	0.25	
AO2	**Mapping of Wind Hazards**		0.5
a	Disseminate wind hazards characterization/zonation	0.25	
b	Develop/improve surge/flood mapping and warning	0.25	
	Subtotal Research Tasks		14
	Subtotal Outreach Tasks		1
	TOTAL COMPONENT A		**15**
B	**ASSESSMENT OF IMPACT OF WIND HAZARDS**		
BR1	**Structural Resistance Using Data Collection**		6
a	Field and laboratory studies of components	2.5	
b	Field and laboratory studies of subsystems and comp. sys.	2.5	
c	Development and validation of structure-level tools	1	
BR2	**Tools for Simulation and Modeling**		6
a	Development of models for components	0.5	
b	Develop models for subassemblies and global systems	1	
c	Dev. computational modeling of wind load & response	2	
d	Collaborative development of software and tools	1	
e	Develop large-scale database and visualization tools	1.5	

BR3	**Tools for System-Level/Wind Loss Assessment**		1.5
a	Validation employing existing loss estimation	0.5	
b	Improve damage and fragility models	0.5	
c	Improve indirect loss estimation	0.5	
BO1	**Structural Resistance Using Data Collection**		0.45
a	Develop research plan for needed experiments	0.15	
b	Develop implementation strategy for sensors	0.15	
c	Develop consensus guidelines for operation of sensors	0.15	
BO2	**Tools for Simulation and Modeling**		1.3
a	Create new models for use in computer software	1	
b	Form consensus-based organization for discussion of software	0.15	
c	Dev. strategy to utilize high-end computational infrastructure.	0.15	
BO3	**Tools for System-Level/Wind Loss Assessment**		1.65
a	Develop next-generation loss estimation tools	1	
b	Develop outreach plan for improving bldg inventory	0.15	
c	Work with communities to create databases for loss est.	0.5	
	Subtotal Research Tasks		13.5
	Subtotal Outreach Tasks		3.4
	TOTAL COMPONENT B		**16.9**
C	**REDUCTION OF IMPACT OF WIND HAZARDS**		
CR1	**Retrofit of Existing Buildings and Structures**		4.5
a	Determine strength of existing and new materials	2	
b	Perform in-situ character. of mat. comp. & systems	2	
c	Develop effective strategies for retrofit	0.5	
CR2	**Innovative Strategies for New Buildings & Structures**		1
a	Develop cost effective innovative technologies	1	
CR3	**Land Use Measures and Cost Effective Construction**		0.5
a	Develop policy for land use and construction practices	0.5	
CR4	**Cost Effectiveness of Wind Loss Mitigation**		1.5
a	Define performance measures	0.5	
b	Improve loss estimation models	0.5	
c	Develop demonstration studies	0.25	
d	Demonstrate application of tools in post-event setting	0.25	
CR5	**Financial Instruments to Transfer Risks**		1.5
a	Collect & disseminate insured wind loss data	0.75	
b	Assess effectiveness of risk transfer methods	0.25	

c	Perform cost-benefit analysis targeting various stakeholders.	0.25	
d	Analyze insurance industry issues	0.25	
CR6	**Technologies for Emergency Response and Recovery**		3.75
a	Develop tools for real-time monitoring of wind hazards	2	
b	Develop real-time loss estimation tools for wind hazards	0.5	
c	Dev. remote sensing techn. for wind damage assessment	0.75	
d	Adapt/develop advanced decision support systems	0.5	
CO1	**Codes, Guidelines and Demonstration Projects**		1
a	Develop guides, manuals of practice and model codes	0.25	
b	Develop products for performance-based design	0.25	
c	Conduct demonstration projects involving res. & practice	0.25	
d	Conduct short courses on new techn., codes & guides	0.25	
CO2	**Financial Instruments to Transfer Risks**		1.75
a	Collect insured loss data after major wind events	0.5	
b	Develop publicly available database on these events	1	
c	Perform case studies on benefits of wind haz. risk transfer	0.25	
CO3	**Technologies for Emergency Response and Recovery**		2.25
a	Integrate loss estim. tools with real-time information	0.75	
b	Develop/apply methodologies for post-event loss update	0.5	
c	Develop decision support tools using various data	0.5	
d	Incorporate data/networking research from other fields	0.5	
	Subtotal Research Tasks		12.8
	Subtotal Outreach Tasks		5.0
	TOTAL COMPONENT C		**17.8**
D	**ENHANCEMENT OF COMMUNITY RESILIENCE, EDUCATION AND OUTREACH**		
DC	**COMMUNITY RESILIENCE TO WIND HAZARDS**		3
DCR	**Research Tasks**		1
a	Develop methodologies for assessment of effectiveness	0.5	
b	Investigate social impacts of significant wind events	0.25	
c	Investigate decision making & wind hazards risk perception	0.25	
DCO	**Outreach Tasks**		2
a	Provide decision tools for relevant stakeholders	1	
b	Develop process for improving regulatory system	0.5	
c	Develop new methodologies and demonstrations	0.5	
DEP	**EDUCATION AND PUBLIC OUTREACH**		9.1
DEP1	**Pre-College (K-12)**		1

a	Enhance curriculum in meteorology, wind engineering	0.5	
b	Develop programs for K-12, incl. summer internships/camps	0.5	
DEP2	**College - Undergraduate Program**		2.0
a	Enhance curriculum in meteorology, wind & structural engineering	0.5	
b	Establish internship programs for junior & seniors	1	
c	Programs for underrepresented groups, women & minorities	0.5	
DEP3	**College - Graduate Program**		4.0
a	Scholarships/Assistantships for MS and PhD programs	2.5	
b	Programs for participation in wind damage investigations	0.5	
c	Develop practice oriented masters degree programs	0.5	
d	Programs for underrepresented groups, women & minorities	0.5	
DEP4	**Continuing Education**		0.9
a	Short courses on advances in wind eng & related disciplines	0.4	
b	Training courses in emerging tech using IT & other tech	0.5	
DEP5	**Public Awareness & Outreach**		1.2
a	Enhance media relations & communication	0.1	
b	Support for nat. and internat. confs., workshops., pub mtgs.	0.5	
c	Information dissemination via helpline, web-based tech	0.25	
d	Prepare articles for public media	0.1	
e	Hold annual public mtg. on advances in wind eng & wind hazards	0.25	
	Subtotal Research Tasks		1.0
	Subtotal Outreach Tasks		11.1
	TOTAL COMPONENT D		**12.1**
	GRAND TOTAL ALL COMPONENTS		**61.8**
