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# CALM BEFORE THE STORM: REAUTHORIZING THE NATIONAL WINDSTORM IMPACT REDUCTION PROGRAM

## JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTEENTH CONGRESS

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# CALM BEFORE THE STORM: REAUTHORIZING THE NATIONAL WINDSTORM IMPACT REDUCTION PROGRAM

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**WEDNESDAY, DECEMBER 4, 2019**

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY,
JOINT WITH THE SUBCOMMITTEE ON ENVIRONMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
*Washington, D.C.*

The Subcommittees met, pursuant to notice, at 2:33 p.m., in room 2318 of the Rayburn House Office Building, Hon. Haley Stevens [Chairwoman of the Subcommittee on Research and Technology] presiding.

**U.S. HOUSE OF REPRESENTATIVES**
**SUBCOMMITTEE ON RESEARCH & TECHNOLOGY**
**AND SUBCOMMITTEE ON ENVIRONMENT**
**COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY**
**HEARING CHARTER**

*Calm Before the Storm: Reauthorizing the National Windstorm Impact Reduction Program*

Wednesday, December 4, 2019
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

**PURPOSE**

On Wednesday, December 4, 2019, the Subcommittee on Research and Technology and the Subcommittee on Environment of the U.S. House of Representatives Committee on Science, Space, and Technology will hold a joint hearing titled, *"Calm Before the Storm: Reauthorizing the National Windstorm Impact Reduction Program."* The purpose of this hearing is to review the activities of the National Windstorm Impact Reduction Program (NWIRP) and to consider opportunities and challenges to improved wind resilience and priorities for the next NWIRP reauthorization.

**WITNESSES**

- **Dr. Scott Weaver**, Director of the National Windstorm Impact Reduction Program, National Institute of Standards and Technology
- **Major General Lee Tafanelli,** Kansas Adjutant General, Director of Kansas Homeland Security and Director of Emergency Management
- **Dr. Delong Zuo,** Associate Professor of Civil Engineering, National Wind Institute, Texas Tech University
- **Mr. Ryan Colker,** Vice President of Innovation and Executive Director of the Alliance for National and Community Resilience, International Code Council

**OVERARCHING QUESTIONS**

- To what extent has NWIRP improved the understanding of windstorms, improved windstorm impact assessment, and reduced windstorm impacts?
- How does NWIRP facilitate interdisciplinary research, including across atmospheric science, engineering, and social sciences, and the translation of that research into reduced windstorm impacts?
- What are the additional needs in research, workforce, and infrastructure for improved wind resilience? How can NWIRP address those gaps?

- What is the role of public-private partnerships in improving wind resilience and how can NWIRP facilitate those partnerships?

**BACKGROUND**

Windstorms, including hurricanes, tropical storms, tornadoes, and thunderstorms, occur in all 50 states and many U.S. territories. These storms, combined with associated flooding, are the largest loss-producing natural hazard in the U.S. and caused over 5,000 fatalities and over $1 trillion in economic losses between 1980 and 2017.[1] The average annual total economic loss for the 10-year period ending in 2015 caused by these windstorms was 73 percent of the total losses and 75 percent of insured losses caused by all hazards.[2] Severe windstorms can compromise national security when they inflict major damage to critical infrastructure, such as defense facilities, ports, airports, communication and power grids, critical manufacturing, financial services and nuclear facilities.[3] According to the Congressional Budget Office (CBO), costs associated with hurricanes are forecast to increase more rapidly than the growth of the economy; annual losses from hurricanes will increase from 0.16 percent of the GDP to 0.22 percent of GDP by 2075.[4] An April 2019 CBO report stated that residential, commercial and public sectors' annual losses from hurricane winds and storm-related flooding is expected to total $54 billion.[5]

**NATIONAL WINDSTORM IMPACT REDUCTION PROGRAM**

The purpose of the National Windstorm Impact Reduction Program (NWIRP) is "to achieve major measurable reductions in the losses of life and property from windstorms through a coordinated Federal effort, in cooperation with other levels of government, academia, and the private sector, aimed at improving the understanding of windstorms and their impacts and developing and encouraging the implementation of cost-effective mitigation measures to reduce those impacts."[6] The National Institute of Building Sciences' "Natural Hazard Mitigation Saves: 2018 Interim Report" found that communities across the nation could see a benefit-cost ratio of $10 for every $1 invested in meeting common code requirements for wind mitigation. NWIRP was established in 2004 [P.L. 108-360]. When Congress reauthorized the program in 2015 in the National Windstorm Impact Reduction Act Reauthorization [P.L. 114-52] it amended the law to direct the National Institute of Standards and Technology (NIST) to be the lead agency rather

[1] Strategic Plan for the National Windstorm Impact Reduction Program, page 3.
[2] 2015 Annual Global Climate and Catastrophe Report, Impact Forecasting, Aon-Banfield, 2016 http://thoughtleadership.aonbenfield.com/Documents/20160113-ab-if-annual-climate-catastrophe-report.pdf
[3] Strategic Plan, page 5.
[4] Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget, CBO, June 2016. https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/51518-hurricane-damage-onecol.pdf
[5] https://www.cbo.gov/system/files/2019-04/55019-ExpectedCostsFromWindStorm.pdf
[6] National Windstorm Impact Reduction Program Act Reauthorization of 2015 [P.L.114-52].

than the White House Office of Science and Technology Policy. Authorization for NWIRP expired in 2017.

**PROGRAM AGENCIES AND COORDINATED BUDGET**

The four program agencies under NWIRP are NIST, the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the Federal Emergency Management Agency (FEMA). Research and activities under this program address three primary mitigation components: improved understanding of windstorms; windstorm impact assessment; and windstorm impact reduction. The 2015 NWIRP Act established an Interagency Coordinating Committee on Windstorm Impact Reduction (ICC) to oversee the planning and coordination of the program. The ICC is composed of the four program agencies plus the Office of Management and Budget and any other appropriate Federal agencies. Congress also requires the ICC to develop a coordinated budget for the program. The four program agencies carry out research and activities to achieve the goals of NWIRP; however, NWIRP does not appear as a line item in the agencies' budgets. The total authorization for the program across all four agencies is $21.4 million for each of fiscal years 2015 through 2017.

**NIST RESEARCH AND ACTIVITIES**

As the lead agency for NWIRP, NIST is responsible for ensuring the program has the necessary components to promote windstorm risk reduction measures; supporting the development of performance-based engineering tools and the commercial application of such tools; requesting assistance from other Federal agencies as needed; coordinating Federal post-windstorm investigations; and issuing recommendations to assist in development of model codes. In addition to lead agency responsibilities, NIST also carries out research and development to improve model building codes, voluntary standards, and best practices for the design, construction, and retrofit of buildings, structures, and lifelines, such as utility and transportation infrastructure. Congress authorized $4.12 million to be appropriated to NIST for each of fiscal years 2015 through 2017 to carry out activities under NWIRP. In FY 2019, NIST spent $5.7 million for NWIRP activities. This figure reflects an allocation to support the Hurricane Maria Investigation.

Using its authority under the National Construction Safety Team Act and NWIRP, NIST announced in 2018 that it planned to study the impact of Hurricane Maria on Puerto Rico, focusing on the performance of critical buildings, electric and water infrastructure, and emergency communications.[7] NIST also conducted an investigation of the 2011 Joplin Missouri tornado and made 16 recommendations for improvements to building design and construction in

[7] https://www.nist.gov/news-events/news/2018/05/nist-launches-study-hurricane-marias-impact-puerto-rico

tornado-prone regions, improvement to emergency communications, and recommended codes and standards be adopted on a national basis for tornado resiliency.

**NSF RESEARCH**

NSF's NWIRP-related activities include supporting research in engineering and atmospheric sciences to improve understanding of the behavior of windstorms and their impact on buildings, structures, and lifelines and economic and social factors influencing windstorm risk reduction measures. NSF also supports windstorm research through its Natural Hazards Engineering and Research Infrastructure (NHERI) program that is a distributed, multi-user, national facility to provide the natural hazards engineering community with access to research infrastructure, including wind engineering experimental facilities, cyberinfrastructure, computational modeling and simulation tools, and research data. The wind tunnels supported under NHERI simulate hurricane and other strong winds; there is no tornado research facility in the United States to simulate vortex winds at scale. The Wind Engineering, Energy and Environment (WindEEE) Dome in Ontario at Canada's Western University is the only facility in the world to conduct tornado-wind simulations to scale. Congress authorized $9.682 million to be appropriated for each of fiscal years 2015 through 2017 to NSF to carry out activities under NWIRP. In FY17, the NSF actual budget spending was $47 million for NWIRP activities. NSF arrives at its actual spending level by adding up all relevant grants across the disciplines at the end of each fiscal year. It is a time-consuming process and NSF was not able to provide the Committee FY19 spending levels in time for this hearing.

**NOAA RESEARCH**

Under NWIRP, NOAA supports atmospheric science research to improve the understanding of the behavior of windstorms. NOAA conducts windstorm related research to help improve wind-related forecasts and warnings, with a focus on improving research to operations integration. NOAA has several activities at the National Weather Service (NWS) and the Office of Oceanic and Atmospheric Research (OAR) that contribute to the goals of NWIRP. These activities largely fall into two categories: hurricanes and local severe weather. Current hurricane related activities at NOAA that support the goals of NWIRP include the Hurricane Forecast Improvement Project and the operation of both the National Hurricane Center's Joint Hurricane Testbed and the Atlantic Oceanographic Meteorological Laboratory's Hurricane Research Division. Current severe weather (tornadoes, derechos, and severe thunderstorms) activities include improving hazardous weather and aviation weather forecasts through the continued development of "Warn on Forecast," operation of the Storm Prediction Center and its Hazardous Weather Testbed, operation of the National Severe Storms Laboratory, and operation of the Earth Systems Research Laboratory's Global Systems Division which includes the High-Resolution Rapid Refresh (HRRR) forecasts. Congress authorized $2.266 million to be appropriated to NOAA for each of fiscal years 2015 through 2017 to carry out NWIRP activities.

In FY 2019, NOAA spent $20.5 million in support of the goals of NWIRP. This figure includes hurricane supplemental funds for that year.

**FEMA ACTIVITIES**

To help achieve the goals of NWIRP, Congress tasked FEMA with supporting 1) the development of risk assessment tools and effective mitigation techniques; 2) windstorm-related data and collection analysis; 3) public outreach and information analysis; and 4) promotion of the adoption of windstorm preparedness and mitigation measures. FEMA's loss modeling software, Hazus, uses standardized methodology to estimate potential losses from natural hazards, including hurricanes. Under NWIRP, Congress also directed FEMA to work closely with national standards and model building code organizations, in conjunction with NIST, to promote implementation of research results and promote better building practices within the building design and construction industry. Congress authorized $2.26 million to be appropriated for each of fiscal years 2015 through 2017 to FEMA to carry out activities under NWIRP. The agency spent $300,000 towards NWIRP-related activities in FY 2019.

**ADVISORY COMMITTEE RECOMMENDATIONS**

The 2015 NWIRP Act directed NIST to establish an Advisory Committee on Windstorm Impact Reduction (ACWIR) with representatives from research and academic institutions, industry standards development organizations, emergency management agencies, state and local government, and business communities, including the insurance industry. The ACWIR report makes three recommendations for the program[8], including:

1) *place a greater emphasis on developing tools for evaluating the windstorm resistance of existing buildings and other infrastructure and for providing practical cost-effective guidance on retrofitting these buildings and other infrastructure to improve their windstorm resistance;*
2) *conduct and promote social science research that provides a greater understanding of the portfolio of public policy approaches for promoting windstorm mitigation; and*
3) *expand to consider all effects of land falling hurricanes, including water intrusion and water induced forces from waves, surge, and flooding, including rainfall related flooding, near the coast.*

[8] Assessments of and Recommendations for the National Windstorm Impact Reduction Program and its Implementation, A Report from the National Advisory Committee on Windstorm Impact Reduction, September 2017. https://www.nist.gov/system/files/documents/2017/10/12/nacwir_assessments_and_recommendations_for_nwirp.pdf

Chairwoman STEVENS. This hearing will come to order. Without objection, the Chair is authorized to declare recess at any time. Good afternoon, and welcome to this joint hearing of the Subcommittees on Research and Technology and Environment to review the National Windstorm Impact Reduction Program, known as NWIRP. Welcome to our distinguished panel of witnesses. I look forward to your testimony.

Tornadoes, thunderstorms, hurricanes, and associated flooding are the deadliest and most costly natural hazards in the Nation. The National Weather Service reported that in 2018, 75 people lost their lives in wind-related storms, and another 80 died in flood-related events. The devastation caused by these storms have become synonymous with their locations and names. The tornadoes of Moore, Oklahoma and Joplin, Missouri, as well as Hurricanes Ike, Katrina, Sandy, Maria, Harvey, and so many more. Every State in the country is exposed to windstorm hazards from one or more storm types, including tornadoes, tropical cyclones, thunderstorms, Nor'easters, winter storms, mountain downslope winds, derechos, and others.

Unfortunately, the costs associated with hurricanes are predicted to increase faster than we can pay for them. American families, businesses, and public sector organizations are expected to spend $54 billion on hurricane damages alone in 2019. However, we have tools and strategies that exist today that could help decrease these overwhelming statistics. The National Institute of Building Sciences found that communities across the Nation could see a 10-to-1 benefit/cost ratio for every investment made to meet common code requirements for wind mitigation. NWIRP was established in 2004 with three key objectives: Improved understanding of windstorms; improved windstorm impact assessment; and reduced windstorm impacts. Translating our fundamental understanding of wind behavior into reduction of windstorm impact is critical to saving lives and reducing property damage caused by severe windstorms. Understanding human behavior and decisionmaking is also essential to saving lives.

The National Institute of Standards and Technology, NIST, leads NWIRP. The program also supports interdisciplinary science and engineering research, public education, support for improved building codes, and other activities at the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the Federal Emergency Management Agency, FEMA. FEMA supports an annual National Preparedness Month each September to promote family and community disaster and emergency planning. In addition to promoting adoption of current building codes, FEMA seeks to educate the general public about measures individuals can take, for example, knowing the safest places in their homes to hide during a storm. As climate change continues to increase the prevalence and risks of severe weather, the Federal investments through NWIRP provide us with the necessary tools to save lives and reduce the economic costs of windstorms. But implementing these tools requires partnership with local governments, the private sector, and individual Americans. Today's discussion will be in part about how we can continue to strengthen those partnerships.

Authorization for NWIRP expired in 2017. The Science Committee looks forward to engaging with the windstorm research and building code communities and State and local governments on recommendations for reauthorization of this important program, and improving our Nation's resilience to devastating windstorms.

[The prepared statement of Chairwoman Stevens follows:]

Good afternoon and welcome to this joint hearing of the Subcommittees on Research and Technology and Environment to review the National Windstorm Impact Reduction Program, known as "NWIRP." Welcome to our distinguished panel of witnesses. I look forward to your testimony.

Tornadoes, thunderstorms, hurricanes, and associated flooding are the deadliest and most costly natural hazards in the nation. The National Weather Service reported that in 2018, 75 people lost their lives in wind-related storms and another 80 died in flood-related events. The devastation caused by these storms have become synonymous with their locations and names: the tornadoes of Moore, Oklahoma and Joplin, Missouri, as well as Hurricanes Ike, Katrina, Sandy, Maria, Harvey and so many more.

Every state in the country is exposed to windstorm hazards from one or more storm types, including tornadoes, tropical cyclones, thunderstorms, Nor'easters, winter storms, mountain downslope winds, derechos, and others.

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The National Institute of Building Sciences found that communities across the nation could see a 10 to 1 benefit-cost ratio for every investment made to meet common code requirements for wind mitigation. NWIRP was established in 2004 with three key objectives—improved understanding of windstorms, improved windstorm impact assessment, and reduced windstorm impacts.

Translating our fundamental understanding of wind behavior into reduction of windstorm impact is critical to saving lives and reducing property damage caused by severe windstorms. Understanding human behavior and decision making is also essential to saving lives.

The National Institute of Standards and Technology, NIST, leads NWIRP. The Program also supports interdisciplinary science and engineering research, public education, support for improved building codes, and other activities at the National Science Foundation, the National Oceanic and Atmospheric Administration, and the Federal Emergency Management Agency.

FEMA supports an annual National Preparedness Month each September to promote family and community disaster and emergency planning. In addition to promoting adoption of current building codes, FEMA seeks to educate the general public about measures individuals can take, for example knowing the safest places in their homes to be during a storm. As climate change continues to increase the prevalence and risks of severe weather, the Federal investments through NWIRP provide us with the necessary tools to save lives and reduce the economic costs of windstorms.

But implementing these tools requires partnership with local governments, the private sector, and individual Americans. Today's discussion will be in part about how we can continue to strengthen those partnerships.

Authorization for NWIRP expired in 2017. The Science Committee looks forward to engaging with the windstorm research and building code communities and State and local governments on recommendations for reauthorization of this important program and improving our nation's resilience to devastating windstorms.

Chairwoman STEVENS. Before I recognize Dr. Baird for his opening statement, I would like to present for the record two letters from the American Society of Civil Engineers and Florida International University.

The Chair now recognizes Dr. Baird for an opening statement.

Mr. BAIRD. Good afternoon, and thank you, Chairwoman Stevens and Chairwoman Fletcher. I want to thank both of you for holding this joint hearing today. I appreciate the witnesses being here as well. I look forward to hearing from the progress the National

Windstorm Impact Reduction Program, NWIRP, has made since its reauthorization in 2015.

Millions of Americans live in areas vulnerable to hurricanes, tornadoes, and other windstorms. Due to shifts in populations, more than 50 percent of Americans now live on a coast or in Tornado Alley. Americans today are more vulnerable than ever to severe weather events. Every year families, and communities, and businesses suffer as lives are lost, and property is damaged. We spend billions of dollars each year on recovery efforts, and these are only expected to grow. That's why we need cost-effective measures to reduce the impact of windstorms on lives, buildings, and infrastructure. NWIRP was created to improve our understanding of windstorms, and to encourage the implementation of cost-effective mitigation measures. It will be good to hear from this program as proactively supporting research and development programs to save lives and reduce property damage caused by these horrific storms.

One key element of NWIRP is the coordination of Federal agency research efforts in cooperation with other levels of government, academia, and the private sector. One example of NWIRP's research efforts is the National Hazards Engineering Research Infrastructure (NHERI) network at the National Science Foundation. To make that brief, that's NHERI. We've got acronyms for everything around here, you know? NHERI provides a network of shared state-of-the-art research facilities and tools at universities around the country to help better understand and withstand the impacts of natural hazards.

Purdue University, in my district, is leading the NHERI Network Coordination Office. The Coordination Office facilitates shared technical knowledge and best practices among the network of eight experimental facilities. This network allows hazard researchers to explore and test groundbreaking concepts of protecting our homes, our businesses, our infrastructure, lifelines, and to enable innovations that mitigate the damages from these natural hazards. The office also leads education and outreach, and the development of strategic partnerships around the world. The goal is for these partnerships to lead a coordinated global natural hazards engineering research infrastructure that fosters collaboration in new ways. These critical investments also offer educational opportunities to the students who will engineer our communities, and plan our disaster response in the future. These investments in R&D (research and development) activities support the creation of improved windstorm impact reduction measures, such as increased warning time, and the development of safe room building guidance.

We know that these measures have the potential to save lives and reduce losses associated with hurricanes, tornadoes, and other severe wind hazards, but may not have been widely adopted. NWIRP is directed to conduct research—development to help improve building codes, voluntary standards, and construction practices to improve the resilience of structures to windstorms. While it has been some success, I look forward to hearing from our witnesses on how we can better improve the transfer of this research to the building code communities. In addition, I look forward to hearing what steps NWIRP is taking to improve public outreach and information dissemination, and the promotion of the adoption

of windstorm preparedness and mitigation measures, and what could be improved.

I would like to thank our witnesses for taking the time to join us here today, and share your experience and your expertise, and I look forward to hearing from you. And, with that, I yield back the balance of my time.

[The prepared statement of Mr. Baird follows:]

Good afternoon Chairwoman Stevens and Chairwoman Fletcher. Thank you both for holding this joint hearing today.

I look forward to hearing about the progress the National Windstorm Impact Reduction Program (NWIRP) has made since its reauthorization in 2015.

Millions of Americans live in areas vulnerable to hurricanes, tornadoes and other windstorms.

Due to shifts in population, more than 50 percent of Americans now live on a coast or in tornado alley.

Americans today are more vulnerable than ever to severe weather events.

Every year families, communities, and businesses suffer as lives are lost and property is destroyed.

We spend billions of dollars each year on recovery efforts and these are only expected to grow.

That's why we need cost effective measures to reduce the impact of windstorms.

NWIRP was created to improve our understanding of windstorms and to encourage the implementation of cost-effective mitigation measures.

It will be good to hear how this program is proactively supporting research and development to save lives and reduce property damage caused by these horrific storms.

One key element of NWIRP is the coordination of Federal agency research efforts, in cooperation with other levels of government, academia, and the private sector.

One example of NWIRP's research efforts is the Natural Hazards Engineering Research Infrastructure network at the National Science Foundation.

NHERI provides a network of shared, state-of-the-art research facilities and tools at universities around the country to help us better understand and withstand the impacts of natural hazards.

Purdue University in my district is leading the NHERI Network Coordination Office.

The Coordination Office facilitates shared technical knowledge and best practices among the network of eight Experimental Facilities.

This network allows hazards researchers to explore and test ground-breaking concepts for protecting our homes, businesses and infrastructure lifelines, and to enable innovations that mitigate the damages from natural hazards.

The Office also leads education and outreach and the development of strategic partnerships around the world.

The goal is for these partnerships to lead to a coordinated, global natural-hazards engineering research infrastructure that fosters collaboration in new ways.

These critical investments also offer educational opportunities to the students who will engineer our communities and plan our disaster response in the future.

These investments in R&D activities support the creation of improved windstorm impact reduction measures, such as increased warning time and the development of safe room building guidance.

We know that these measures have the potential to save lives and reduce losses associated with hurricanes, tornados, and other severe wind hazards, but have not been widely adopted.

NWIRP is directed to conduct research and development to help improve building codes, voluntary standards, and construction practices to improve the resilience of structures to windstorms.

While it has seen some success, I look forward to hearing from our witnesses on how we can better improve the transfer of this research to the building code communities.

In addition, I look forward to hearing what steps NWIRP is taking to improve public outreach and information dissemination.

I would like to thank our witnesses for taking the time to join us today to share your experience and expertise.

Chairwoman STEVENS. Thank you. The Chair now recognizes Mrs. Fletcher for an opening statement.

Chairwoman FLETCHER. Thank you, Chairwoman Stevens. I join you, and Ranking Members Baird and Marshall, in welcoming all of you today for today's joint hearing between the Research and Technology and the Environment Subcommittees on reauthorizing National Windstorm Impact Reduction Program, NWIRP. NWIRP was established in 2004 to improve understanding of windstorms and their impacts, and to work to mitigate those impacts in a cost-effective way. The overall success of this program can be attributed to its inter-agency approach, led by the National Institute of Standards and Technology, or NIST, which helps to streamline Federal efforts, and leverage existing programs and activities.

Windstorms affect all 50 States, and many territories, through severe weather events, such as hurricanes, tornadoes, and thunderstorms. Unfortunately, my constituents in Houston know all too well the wind damage that we see from hurricanes, and the devastating impact that they can have. And, in fact, the scale used to grade hurricanes is based upon hurricane sustained wind speeds, and its potential to cause life and property damage. In Texas we're familiar with that as well, with tornadoes and strong thunderstorms in other parts of the State, as well as—we have seen more recently in Houston. That is why I'm so pleased that one of our witnesses, Dr. Zuo, is from the National Wind Institute based at Texas Tech University. It's crucial that we understand and identify interdisciplinary research needs so that we can improve the outcomes of NWIRP.

On the Environment Subcommittee we've already discussed many of NOAA's programs and activities that support the goals of NWIRP. The agency's windstorm related research falls largely within the categories of hurricanes and other local severe weather, including tornadoes and thunderstorms. NOAA's operational role of providing windstorm forecasts and conducting post-event assessments, and its commitment to improving the integration of research to operations, is also a vital part of meeting NWIRP's goals.

Programs like NWIRP will also benefit from NOAA's ongoing efforts to improve the accuracy, lead time, and dissemination of weather forecasts through the implementation of the *Weather Research Forecasting Innovation Act*, and the recently established Earth Prediction Innovation Center, or EPIC. Today's discussion will inform this Committee's work to reauthorize an interagency program that engages stakeholders across a variety of sectors, represented by our distinguished panel.

I look forward to hearing from our non-Federal witnesses on how their organizations have successfully utilized the outcomes of the program, and their recommendations on how NWIRP can be improved. It is critical for this Committee, and Congress overall, to continue its work in evaluating and reauthorizing existing programs that have a successful track record of providing benefits for all of our constituents. Thank you, and I yield back.

[The prepared statement of Chairwoman Fletcher follows:]

Good afternoon. I would like to join Chairwoman Stevens in welcoming you to today's joint hearing between the Research and Technology, and Environment Subcommittees on reauthorizing the National Windstorm Impact Reduction Program or NWIRP.

NWIRP was established in 2004 to improve the understanding of windstorms and their impacts, and to work to mitigate those impacts in a cost-effective way. The

overall success of this program can be attributed to its interagency approach, led by the National Institute of Standards and Technology, or NIST, which helps to streamline federal efforts and leverage existing programs and activities.

Windstorms affect all 50 states and many territories through severe weather events such as hurricanes, tornadoes, and thunderstorms.

Unfortunately, my constituents in Houston, Texas are all too familiar with high winds from hurricanes and the damage they can cause. In fact, the Saffir-Sampson hurricane wind scale used to grade hurricanes is based upon a hurricane's sustained wind speeds and its potential to cause loss of life and property damage. My home state of Texas is also familiar with tornadoes and strong thunderstorms, which is why I am pleased to see that one of our witnesses, Dr. Delong Zuo, is from the National Wind Institute based at Texas Tech University. It is crucial that we understand and identify interdisciplinary research needs so we can improve the outcomes of NWIRP.

On the Environment Subcommittee we have already discussed many of NOAA's programs and activities that support the goals of NWIRP. The agency's windstorm related research falls largely within the categories of hurricanes and other local severe weather including tornadoes and thunderstorms. NOAA's operational role of providing windstorm forecasts and conducting post event assessments, and its commitment to improving the integration of research to operations, is also a vital part of meeting NWIRP's goals.

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Thank you and I yield back.

Chairwoman STEVENS. Thank you, and the Chair now recognizes Dr. Marshall for an opening statement, and thank you so much, sir, for your tremendous leadership in today's hearing.

Mr. MARSHALL. Thank you, Chairwoman Stevens and Chairwoman Fletcher, for holding this hearing. I appreciate this Committee's focus on improving forecasting the effects of severe weather events this Congress. Today's hearing builds on our previous work. It examines how we translate the knowledge gained from an improved forecast and use that to help our constituents better prepare for severe weather events, wind damage in this case.

Damage from severe wind effects from tornadoes and thunderstorms is a phenomenon Kansans know too well, and it's certainly a tragedy that I know too well personally. One of our witnesses will recall the Greensburg Tornado of 2007, an F5 tornado that left 14 people dead. That tornado continued northward. By the time it got to my property, it was a mile wide. It literally looked like someone had taken a lawnmower, set it about 6′ off the ground, and mowed off everything above 6′. The tornado decided I didn't need my porch, I didn't need my roof, and my barn should be repositioned. It was certainly a devastating night that I'll never forget. It was just 6 years earlier, prom night, in Hoisington, Kansas that an F4 tornado took about a third of the city out. Many of my friends', my patients' homes were damaged. Amazingly, only one fatality. And I'll always remember seeing the widow of that fatality the next week in my office.

Farmers and ranchers face the constant threat of damaged equipment and lost crops due to severe weather. Homeowners in

rural communities, towns, and cities all face the same prospect of damage to their homes. First responders and emergency personnel must be prepared for these events at a moment's notice. The National Windstorm Impact Reduction Program, more commonly known as NWIRP, was created by Congress in 2004. The legislation was written to help reduce the loss of life and property by ensuring a coordinated Federal response, and working with different levels of government, and private sector, and the research community in better understanding windstorms, and mitigating their impacts.

NWIRP was reauthorized in 2015, and placed the National Institute of Standards and Technology in charge of coordinating Federal efforts. In the years since the program was created, we have made significant progress in understanding and mitigating the impacts of wind damage. NOAA has made strides in its ability to forecast extreme weather, and will continue to do so thanks to weather-related legislation passed by this Committee. The National Science Foundation has engaged in research which has helped to improve the communication of severe weather events to the public. NIST has led research which has resulted in improved building standards for communities across the country, but we must strive to doing more as we consider reauthorizing this program. Questions this Committee should ask include can we further improve the coordination of the Federal agencies involved in these efforts? How can we assist communities in adopting and utilizing the research generated through these efforts?

I want to think our panel of witnesses for appearing today here with us, and help answer our questions. Our witnesses represent government, academic, and private-sector perspectives, and I look forward to a conversation about how we continue to press this important issue. My only regret today is my dad's not here with us. My dad was the Chief of Police in El Dorado, Kansas for 25 years, and it was his responsibility to decide when do you blow the sirens? When do you blow that tornado siren? And I remember many a night standing out on a turnpike on an overpass, watching the clouds as they came closer, and my dad trying to decide, do we blow the sirens or not? And it's my hope that the science that we can discover here, the improved emergency systems that we have, can lead to more safety, and take pressure off those people that are trying to make those life and death decisions. So thank you, Madam Chair, and I yield back.

[The prepared statement of Mr. Marshall follows:]

Thank you for holding this hearing, Chairwoman Stevens and Chairwoman Fletcher.

I appreciate this committee's focus on improving forecasting the effects of severe weather events this Congress. Today's hearing builds on our previous work and examines how we can translate the knowledge gained from improved forecasts and use that to help our constituents better prepare for severe weather events—wind damage in this case.

Damage from severe wind effects from tornadoes and thunderstorms is a phenomenon Kansans know well. Farmers and ranchers face the constant threat of damaged equipment and lost crops due to severe weather. Homeowners in rural communities, towns, and cities all face the same prospect of damage to their homes. First responders and emergency personnel must be prepared for these events at a moment's notice.

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duce the loss of life and property by ensuring a coordinated federal response in working with different levels of government, the private sector, and the research community in better understanding windstorms and mitigating their impacts. NWIRP was reauthorized in 2015 and placed the National Institute of Standards and Technology (NIST) in charge of coordinating federal efforts.

In the years since the program was created, we have made significant progress in understanding and mitigating the impacts of wind damage. NOAA has made strides in its ability to forecast extreme weather and will continue to do so thanks to weather-related legislation passed by this Committee. The National Science Foundation has engaged in research which has helped improve the communication of severe weather events to the public. NIST has led research which has resulted in improved building standards for communities across the country.

But we must strive to do more as we consider reauthorizing this program. Questions this committee should ask include: Can we further improve the coordination of the federal agencies involved in these efforts? How can we assist communities in adopting and utilizing the research generated through these efforts?

I want to thank our panel of witnesses for appearing here today who will help us answer these questions. Our witnesses represent government, academic, and private sector perspectives and I look forward to a conversation about how we can continue to address this important issue.

Thank you, Madam Chair. I yield back.

Chairwoman STEVENS. And now we'll recognize the Chair of our entire Science Committee, Chairwoman Johnson, who we are also wishing a very happy belated birthday to today.

Chairwoman JOHNSON. Thank you very much. Let me thank you, Chairwomen Stevens and Fletcher, for holding this hearing. As Chair Fletcher already discussed, the State of Texas has experienced devastating loss of life and property from hurricanes and associated flooding. Texas is also one of the States most vulnerable to tornadoes. When an EF–3 tornado hit my home city of Dallas in October, hundreds of people lost their homes and businesses. Two Dallas schools were destroyed. One estimate puts the economic cost of tornadoes that struck North Texas that night at $2 billion. We are so fortunate that no lives were lost.

The nation is facing increasing natural disasters of all kinds due to the climate change and land use changes. The human and financial toll of these disasters is increasing, not just because of the increased severity and frequency of disasters, but also because of the growing population. The shift is where people are living, and the plan and policy choices made by local and State leaders.

In Texas, building codes are adopted at the city and county level. A new survey of jurisdictions along the Texas coast by the Insurance Institute for Business and Home Safety found that 840,000 Texans live in areas with no adopted residential building code. In its 2018 report, "Rating State Building Code Systems for All Eastern and Southern Coastal States," the same institute gave Texas a score of 34 out of 100. Only three States ranked lower. Florida, on the other hand, received a 95. I hate to say it, but in this case Florida proves that where there's a will, there's a way.

The National Windstorm Impact Reduction Program provides States and local jurisdictions, as well as individual home and business owners, with the tools and information they need to protect their families, their property, and their communities. The risks are increasing, but the 15-year NWIRP program has not received the support it merits, including here in Congress. The program is carrying on even after the expiration of the last reauthorization thanks to the commitment and hard work of the program staff in each of the key agencies. And I applaud them for that, but they are

operating on a shoestring budget at best. We must provide them with the resources and other support to carry out their mission.

Many of us on this Committee are from States that have seen widespread devastation from windstorms, and we will see more. We are from red States, blue States, big cities, rural areas, wealthy and poor States. All of our communities are at risk, and those who are already the most economically vulnerable suffer the most when natural disasters strike.

As you have heard, and will hear from others in the hearing, $1 invested in resilience is $10 saved. Reauthorizing the NWIRP program and providing the agencies with much needed resources will be a priority for this Committee in the new year. I look forward to working with my colleagues on the other side of the aisle, and the same in the Senate. I thank you, and yield back.

[The prepared statement of Chairwoman Johnson follows:]

Thank you, Chairwomen Stevens and Fletcher, for holding this hearing. As Chair Fletcher already discussed, the state of Texas has experienced devastating loss of life and property from hurricanes and associated flooding. Texas is also one of the states most vulnerable to tornadoes. When an EF-3 Tornado hit my home city of Dallas in October, hundreds of people lost their homes or businesses. Two Dallas schools were destroyed. One estimate puts the economic cost of the tornadoes that struck North Texas that night at $2 billion. We are very fortunate that no lives were lost.

This nation is facing increasing natural disasters of all kinds due to climate change and land use changes. The human and financial toll of these disasters is increasing not just because of the increased severity and frequency of disasters, but also because of the growing population, the shift in where people are living, and the planning and policy choices made by local and state leaders.

In Texas, building codes are adopted at the city and county level. A new survey of jurisdictions along the Texas coast by the Insurance Institute for Business and Home Safety found that 840,000 Texans live in areas with no adopted residential building code. In its 2018 report rating state building code systems for all eastern and southern coastal states, the same Institute gave Texas a score of 34 out of 100. Only 3 states ranked lower. Florida, on the other hand, received a 95. I hate to say it, but in this case, Florida proves that where there is a will, there is a way.

The National Windstorm Impact Reduction Program provides states and local jurisdictions, as well as individual home and business owners with the tools and information they need to protect their families, their property, and their communities. The risks are increasing, but the 15-year old NWIRP program has not received the support it merits, including here in Congress. The program is carrying on even after the expiration of the last reauthorization thanks to the commitment and hard work of program staff in each of the key agencies. And I applaud them for that. But they are operating on a shoestring budget at best. We must provide them with the resources and other support to carry out their mission.

Many of us on this Committee are from states that have seen widespread devastation from windstorms. And we will see more. We are from red states and blue states, big cities and rural areas, wealthy and poor states.

All of our communities are at risk, and those who are already the most economically vulnerable suffer the most when natural disasters strike. As you have heard and will hear from others in the hearing, $1 invested in resilience is $10 saved. Reauthorizing the NWIRP program and providing the agencies with much needed resources will be a priority for this Committee in the new year. I look forward to working with my colleagues on the other side of the aisle and in the Senate to get this done.

Chairwoman STEVENS. Thank you, Madam Chair. And now the Chair recognizes Ranking Member Lucas for an opening statement.

Mr. LUCAS. Thank you, Madam Chairwoman, and good afternoon, Chairwoman Stevens, and I'd also like to thank you and Chairwoman Fletcher for holding this joint hearing today on the National Weather Storm Impact Reduction Program.

As a son of Oklahoma, where—and yes, Rogers and Hammerstein were correct—the wind comes sweeping down the plain, efforts to reduce the loss of life and property from windstorms is of extreme importance to my family, my friends, and my neighbors. Oklahoma's part of an area of the Midwest referred to by many as Tornado Alley, and over the last decade, the last 10 years, tornadoes have caused an average financial loss of over $10 billion per year. This May, a four day tornado outbreak produced 190 tornadoes, impacting States across the Rockies, the midwest, the northeast, from Colorado to Oklahoma, and all the way to New Jersey. The estimated cost of this outbreak was $3.2 billion.

Each year, lives are lost, billions are spent recovering from the destruction caused by tornadoes, hurricanes, and windstorms, and the costs associated with windstorms are increasing. NWIRP helps provide coordination between Federal Government agencies, universities, industry, local and State governments. This cooperation is needed to meet the great challenges of responding to windstorms. It is important we continue to support the Federal research done through NWIRP to improve our understanding of windstorms, their impacts, and to develop and enhance mitigation measures.

For example, through NWIRP, NIST is supporting researchers from the University of Oklahoma who are developing maps of damaging winds using data collected from integrated remote and onsite observations. These observations will provide high resolution data in time and space, providing for improved real-time forecasting. NSF and NOAA are also working with the University of Oklahoma on the TORUS (Targeted Observations by Radars and UAS of Supercells) project. The project involves more than 50 researchers and students using different tools to measure the atmosphere, including unmanned aircraft systems, mobile radars, and NOAA's Hurricane Hunter aircraft.

After 32 days on the road, traveling more than 9,000 miles, researchers encountered 19 supercells, with eight of those storms producing tornadoes. Researchers expect results from the TORUS project to be groundbreaking. The insights gained will improve our understanding of why supercells create tornadoes and others do not, leading to improved forecasting. The project is also offering hands-on training in the field for the future workforce. Students taking part in this project will give us better knowledge of windstorms and develop the next generation of applications for reducing future losses. I look forward to what they discover in the 2020 storm season and beyond.

This research is important, but it is also key that we find practical and effective applications for this research, so that it reaches those who need it the most, States and local communities. I understand this is a challenge, but I look forward to hearing today on how NWIRP is working to tackle it, and to better prepare our Nation for windstorms.

I'd like to thank our witnesses for coming today to share their expertise on the challenges, and hopeful successes, of reducing windstorm impacts. Thank you, and I yield back the balance of my time, Madam Chair.

[The prepared statement of Mr. Lucas follows:]

Good afternoon Chairwoman Stevens. I would like to thank you and Chairwoman Fletcher for holding this joint hearing today on the National Windstorm Impact Reduction Program (NWIRP).

As a son of Oklahoma, where—the wind comes sweepin' down the plain—efforts to reduce the loss of life and property from windstorms is of extreme importance to my family, friends, and neighbors. Oklahoma is part of an area of the midwest called "tornado alley." Over the past 10 years, tornados have caused an average financial loss of over $10 billion per year.

This May, a four-day tornado outbreak produced 190 tornados, impacting states across the Rockies, Midwest and Northeast—from Colorado to Oklahoma and all the way to New Jersey. The estimated cost of this outbreak was $3.2 billion.

Each year, lives are lost and billions are spent recovering from the destruction caused by tornadoes, hurricanes and other windstorms. And the costs associated with windstorms are increasing.

NWIRP helps provide coordination between federal government agencies, universities, industry, and local and state governments. This cooperation is needed to meet the great challenge of responding to windstorms.

It is important we continue to support the federal research done through NWIRP to improve our understanding of windstorms, their impacts, and to develop enhanced mitigation measures.

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I would like to thank our witnesses for coming today to share their expertise on the challenges, and hopefully successes, of reducing windstorm impacts.

Thank you and I yield back the balance of my time.

Chairwoman STEVENS. Thank you so much, Mr. Lucas. And if there are other Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I'd like to introduce our incredible witnesses. Our first witness is Dr. Scott Weaver. Dr. Weaver is the Director of the National Windstorm Impact Reduction Program, NWIRP, at the National Institute of Standards and Technology, NIST. Dr. Weaver also holds an appointment as Adjunct Associate Professor in the Department of Atmospheric and Oceanic Science at the University of Maryland. He currently chairs the NWIRP Windstorm Working Group, a Federal inter-agency partnership that carries out coordination and implementation of the NWIRP program. Prior to joining NIST, Dr. Weaver served as the Senior Climate Scientist for the Environmental Defense Fund, and spent several years as a research meteorologist in the Climate Predication Center at NOAA. Thank you so much from bringing your expertise here.

And, at this time, this Chair would also like to ask Dr. Marshall to introduce our next witness.

Mr. MARSHALL. All right. Thank you, Chairwoman Stevens. I'm very proud today to welcome a good personal friend, and a fellow public servant to the people of Kansas, Major General Lee Tafanelli, as a witness today. Welcome, General Tafanelli. It's good to see you here. Major Tafanelli is the Adjutant General of Kansas, and the Director of Kansas Homeland Security and Emergency Management. In these roles, he oversees the activities of the Adjutant General's Department by providing personnel, administration, and training guidance for over 7,000 soldiers and airmen in the Kansas Army and Air National Guard, as well as leadership to the full-time National Guard and State employees of the Department. He's responsible for leading a core group of professionals tasked with preparing and responding to emergency situations within the State of Kansas. This includes guidance and training to 105 county emergency managers and their staffs.

Major Tafanelli has worked to ensure security in the State is a top priority. Prior to his appointment as Adjutant General, Major General Tafanelli was assigned as the Assistant Adjutant General. In addition, he served in the Kansas House of Representatives, representing the 47th District from 2001 to 2011. Major Tafanelli received his commission from Pittsburg State University, where we were both there recently to commission some officers, and is also an Army Reserve Officer Training Corps, and holds a master's degree from one of the top universities in the country, Kansas State University, and the Army War College. Thank you for being here today, Major General, and I yield back.

Chairwoman STEVENS. Excellent. Our next witness is Dr. Delong Zuo. Dr. Zuo is an Associate Professor in the Department of Civil, Environmental, and Construction Engineering at Texas Tech University. He is also the Technical Director of the wind engineering pillar of the National Wind Institute at Texas Tech University. Dr. Zuo's expertise is in the areas of structural dynamics, wind engineering, and wind hazard mitigation. His current research focuses on the assessment of tornadic loading on buildings, and wind-induced vibration of slender structures, such as long-span bridges and towers of various types.

Dr. Zuo is currently the principal investigator of the Wind Hazard and Infrastructure Performance Center, funded by the National Science Foundation, and he also serves as a member of the Strategic Committee of the Network Coordination Office of the Natural Hazards Engineering Research Infrastructure Program supported by NSF.

Our final witness is Mr. Ryan Colker. Mr. Colker is Vice President of Innovation at the International Code Council (ICC), and also serves as the Executive Director of the Alliance for National and Community Resilience, a national coalition working to provide communities with the tools necessary to assess and improve their resilience. Prior to joining ICC, Mr. Colker served as Vice President at the National Institute of Building Sciences, where he led efforts to improve the built environment through the collaboration of public- and private-sector industry stakeholders. At the National Institute of Building Sciences, he directed the Consultative Council,

which develops findings and recommendations on behalf of the entire building community. So it looks like we're in for a good one here.

As our witnesses should know, you will each have 5 minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. And, when you've each concluded your spoken testimony, we'll begin questions, and we'll do that at the conclusion here. Each Member will have 5 minutes to address the panel, and we're going to start with 5 minutes from Dr. Weaver.

**TESTIMONY OF DR. SCOTT WEAVER, DIRECTOR OF THE NATIONAL WINDSTORM IMPACT REDUCTION PROGRAM, NIST**

Dr. WEAVER. Chairwoman Johnson, Ranking Member Lucas, Chairwoman Stevens, Chairwoman Fletcher, Ranking Member Baird, Ranking Member Marshall, and Members of the Subcommittees, I am Dr. Scott Weaver, Director for the National Windstorm Impact Reduction Program, or NWIRP, at the Department of Commerce's National Institute of Standards and Technology, known as NIST. Thank you for the opportunity to appear before you today.

NWIRP is an inter-agency science and engineering-based program focused on achieving major measurable reductions in losses of life and property from windstorms. Since NWIRP's inception in 2004, we have made notable progress toward efforts to reduce windstorm impacts. This includes significant improvements in hurricane forecasts and increased tornado warning times; advancements in the science of wind mapping to inform engineering-based design standards; improved coordination practices and research support for post-windstorm investigations; and implementation of post-windstorm research-based recommendations into codes, standards, and practices. Despite these achievements, the Nation continues to experience increasing losses of life and property due to these extreme weather events, as evidenced by the devastating tornado outbreaks in 2011 and 2013, and the recent catastrophic hurricane seasons of 2005, 2012, 2016, 2017, and 2018.

Windstorms, and associated flooding, are the largest loss-producing natural hazards in the United States. Every State in the country is exposed to windstorm hazards from one or more storm types. During the period from 1980 to 2018, windstorms caused over $1 trillion in economic losses, and over 8,000 fatalities in the U.S. The greatest of these losses are associated with tornadoes and hurricanes. In 2011, six different tornado outbreaks produced a combined damage of $29 billion and 545 fatalities. In a 14-month span from August 2017 to October 2018, five major hurricanes made landfall in the U.S., not including Hurricane Florence, which made landfall as a Category 1 storm measured by wind speed, but which caused catastrophic inland flooding impacts to the Carolinas. The 2017 and 2018 hurricanes caused thousands of fatalities, and comprised approximately 79 percent of the $411 billion total of all extreme weather and climate events over that short period, and future projections indicate that these costs are likely to increase more rapidly than the growth of the economy.

The causes underlying these massive and rapidly increasing windstorm losses are many, varied, and complex. Some are related

to long-term societal changes, such as the movement of population toward coastal areas of the U.S. Others relate to climate variability and change, and other meteorological factors, such as limited understanding of surface level storm characteristics, their associated hazards, and interactions of these hazards on the built environment.

Advances in recent decades in atmospheric science have led to great improvements in forecasting and warning systems for hurricanes, tornadoes, and other windstorms. However, large knowledge gaps remain in aspects of windstorm climatology and hazards near the surface. While great progress has been made in understanding earthquake effects on building, and engineering design to resist those effects, comparatively less progress has been made in engineering for extreme winds and for coastal inundation hazards.

Without additional actions to mitigate windstorm hazards, losses due to windstorms will only continue to increase. I want to thank this Committee for its recognition of the necessary role for the Federal Government and other organizations in supporting windstorm impact reduction, and resulting creation of NWIRP to focus on reducing the loss of life and property from windstorms. NIST, as the lead agency, works closely with other NWIRP designated program agencies, FEMA, NOAA, and NSF to implement the program.

To address the challenges noted previously, in 2018 NWIRP released its strategic plan, which was developed in concert with stakeholders from across government, academia, and the private sector. Contained within the plan are three overarching long-term strategic goals. They are: Improve the understanding of windstorm processes and hazards; improve the understanding of windstorm impacts on communities; and improve the windstorm resilience of communities nationwide.

A signature NIST research activity that is emblematic of these three strategic goals is the current investigation of the effects of Hurricane Maria in Puerto Rico. That study aims to: Better understand how multiple intersecting hazards, such as wind, rainfall, flooding, landslides, and storm surge created the conditions that led to deaths and injuries; evaluate the performance of critical buildings and emergency communication systems; and improve understanding of the impacts to, and recovery of, selected businesses, hospitals, and schools. After the study's completion, NIST will pursue and track implementation of its recommendations in an effort to reduce windstorm impacts nationwide.

NWIRP continues to make strides in implementing the strategy put forth in its strategic plan. However, as losses continue to mount, there is much work to be done. I look forward to discussing the NWIRP program with you today, the progress we've made, and challenges and recommendations for the future. I am pleased to answer any questions you may have. Thank you.

[The prepared statement of Dr. Weaver follows:]

Testimony of

Dr. Scott Weaver
Director
National Windstorm Impact Reduction Program
Engineering Laboratory
National Institute of Standards and Technology
United States Department of Commerce

Before the

Committee on Science, Space, and Technology
Subcommittee on Research and Technology &
Subcommittee on Environment

United States House of Representatives

December 4, 2019

**Introduction**

Chairwoman Stevens, Chairwoman Fletcher, Ranking Member Baird, Ranking Member Marshall and members of the Subcommittees, I am Dr. Scott Weaver, Director for the National Windstorm Impact Reduction Program (NWIRP) at the Department of Commerce's National Institute of Standards and Technology (NIST). NWIRP is an interagency science and engineering based program focused on achieving major measurable reductions in losses of life and property from windstorms, through a coordinated federal effort. Since NWIRP's inception in 2004 we have made notable progress towards efforts to reduce windstorm impacts. This includes significant improvements in hurricane forecasts and increased tornado warning times, advancements in the science of wind mapping to inform engineering-based design standards, improved coordination practices and research support for post windstorm investigations, and implementation of post windstorm research-based recommendations into codes, standards, and practices. Despite these achievements, the Nation continues to experience increasing losses of life and property due to these extreme weather events, as evidenced by the devastating tornado outbreaks in 2011 and 2013, and the recent catastrophic hurricane seasons of 2005, 2012, 2016, 2017 and 2018.

I look forward to discussing the NWIRP program with you today, the progress we've made, challenges and recommendations for the future. Thank you for the opportunity to appear before you to discuss NWIRP.

**Windstorm Impacts in the United States**

Windstorms, and associated flooding, are the largest loss-producing natural hazards in the United States. The greatest of these losses are associated with tornadoes and hurricanes. During the period from 1980 to 2018, windstorms caused over $1 trillion in economic losses and over 8,000 fatalities.[1] Every state in the country is exposed to windstorm hazards from one or more storm types, including tornadoes, tropical cyclones, thunderstorms, nor'easters, winter storms, and others.

Tornadoes occur in all 50 states, but mainly east of the Continental Divide. Over the past 10 years, tornadoes have caused an average loss of approximately $10 billion per year. In 2011, six different tornado outbreaks affected 16 states and produced a combined damage of $29 billion and 545 fatalities.[2] The 2011 Joplin Missouri tornado alone killed 161 people, injured over a thousand, and resulted in nearly $3 billion in insured losses.[3]

Hurricanes primarily impact coastal states along the Atlantic Ocean and Gulf of Mexico, as well as Hawaii and U.S. territories in the Caribbean and the Pacific. 2017 and 2018 were record breaking years for windstorm losses in the United States with Hurricanes Harvey ($130 billion

[1] NOAA National Centers for Environmental Information, U.S. Billion-Dollar Weather and Climate Disasters, 1980-2016 https://www.ncdc.noaa.gov/billions/events.
[2] The complete list of critical infrastructure sectors is given at https://www.dhs.gov/critical-infrastructure-sectors.
[3] Final Report, National Institute of Standards and Technology (NIST) Technical Investigation of the May 22, 2011, Tornado in Joplin, Missouri, NIST NCSTAR-3, March 2014. http://nvlpubs.nist.gov/nistpubs/NCSTAR/NIST.NCSTAR.3.pdf.

estimated damage), Irma ($52 billion estimated damage), Maria ($94 billion estimated), Florence ($25 billion estimated), and Michael ($25 billion estimated) comprising approximately 79 percent of the $411 billion total of all extreme weather and climate events over that period.[1] In a 14 month span from August 2017 through October 2018, five major hurricanes (category 3 or higher) made landfall in the U.S., not including hurricane Florence, which made landfall as a category 1 storm, but caused catastrophic inland flooding impacts to the Carolinas from extreme rainfall.

Other, recent notable hurricane events include Hurricane Sandy (2012), which caused over a $70 billion loss,[1] producing extensive damage in seven states, and Hurricane Katrina (2005), which caused over 1,200 fatalities and a loss in excess of $150 billion, resulting in destructive storm surge along the Louisiana, Mississippi, and Alabama coasts, as well as high winds and damage as far inland as Ohio.

**The Cost of Inaction**

The costs associated with hurricanes are forecast to increase more rapidly than the growth of the economy. The Congressional Budget Office (CBO)[4] projects that average annual losses due to hurricanes will increase from 0.16 percent of gross domestic product (GDP) to 0.22 percent of GDP by 2075. CBO projections include the effects of sea level rise, increased storm activity, population growth, increased coastal development, and increased per capita income in hurricane prone areas. These values do not take into account potential improvements in construction practices, land use practices, and building stock turnover. Similarly, population growth in tornado prone central and southeastern United States will likely result in increased loss of life and damage, unless cost effective measures are taken to reduce the impact of tornadoes on buildings and infrastructure.

The causes underlying these massive and rapidly increasing windstorm losses are many, varied, and complex. Some are related to long-term societal changes, such as the movement of population towards coastal areas in hurricane-prone regions of the U.S.[5] Others relate to climate system variability and change[6], lack of understanding of surface level storm characteristics and their associated hazards (e.g., extreme winds and rainfall, wind-borne debris, atmospheric pressure change, storm surge, and surge-borne debris), interactions of these hazards on the built environment, how to mitigate them, and how to effectively communicate with and educate the public and other stakeholders.

Advances in recent decades in atmospheric science have led to great improvements in forecasting and warning systems for hurricanes, tornadoes, and other windstorms; however, large

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[4] Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget, CBO, June 2016 https://www.cbo.gov/publication/51518.

[5] http://www.census.gov/topics/preparedness/about/coastal-areas.html.

[6] *The Climate Science Supplemental of the National Climate Assessment:* https://science2017.globalchange.gov/

knowledge gaps remain in aspects of windstorm climatology and hazards near the surface. This knowledge is critical for risk assessments and engineering design of the built environment to mitigate the impact of these hazards. Similarly, while great progress has been made in understanding earthquake effects on buildings and engineering design to resist those effects, comparatively less progress has been made in engineering for extreme winds and for coastal inundation hazards of wind-driven storm surge and waves. Without additional actions to mitigate windstorm hazards and thereby reduce windstorm risks, losses due to windstorms will only continue to increase.

**Meeting the Challenge**

In recognition of the necessary role for the Federal Government and other organizations in supporting windstorm impact reduction, Congress created NWIRP in 2004 to reduce the loss of life and property from windstorms (National Windstorm Impact Reduction Act of 2004, Public Law 108-360, Title II). On September 30, 2015, the National Windstorm Impact Reduction Act Reauthorization of 2015 (Public Law 114-52) was enacted, which reauthorized the program, made changes to leadership, oversight, and reporting requirements, modified the roles of the four program agencies, and updated other program aspects.

With Public Law 114-52, the lead agency function for NWIRP was moved to NIST from the Office of Science and Technology Policy (OSTP). In addition to overall leadership and coordination, NIST responsibilities include:

- Ensuring the program includes components necessary to promote the implementation of windstorm risk reduction measures;
- Requesting assistance of federal agencies other than the program agencies, as necessary;
- Coordinating all federal post-windstorm investigations to the extent practicable;
- Supporting the development of performance-based engineering tools and working with appropriate groups to promote the commercial application of such tools; and,
- When warranted by research or investigative findings, issuing recommendations to assist in informing the development of model codes, and providing information to Congress on the use of such recommendations.

There are four designated program agencies: The Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). These agencies work together to implement the program's three statutory components:

- Improved understanding of windstorms,
- Windstorm impact assessment, and
- Windstorm impact reduction.

NWIRP activities span the full spectrum from research through implementation, including basic physical science, social science, and engineering research; problem focused research and codes and standards development; information dissemination, public education and outreach; and promotion of the adoption of windstorm preparedness and mitigation measures.

An Interagency Coordinating Committee oversees the program's planning and coordination, and consists of the heads or designees of FEMA, NOAA, NSF, the Office of Science and Technology Policy (OSTP), and the Office of Management and Budget (OMB), and is chaired by the Director of NIST or the Director's designee. A new Windstorm Working Group (WWG) was created in 2016 to provide closer program coordination at the working level.

**A Vision for Windstorm Impact Reduction in the United States**

To address the challenges discussed above, in 2018, NWIRP released its Strategic Plan - a comprehensive strategy developed in concert with stakeholders from across government, academia, and the private sector. The plan includes vision and mission statements, and goals to guide holistic windstorm impact reduction actions.

> ***The NWIRP Vision is:***
>
> *A nation that is windstorm-resilient in public safety and economic well-being.*
>
> ***The NWIRP Mission is:***
>
> *To achieve major measurable reductions in the losses of life and property from windstorms through a coordinated federal effort, in cooperation with other levels of government, academia, and the private sector. NWIRP will support research aimed at improving the understanding of windstorms and their impacts, and develop technical guidance and support outreach initiatives encouraging the implementation of cost-effective mitigation measures to reduce those impacts.*

Three overarching, long-term Strategic Goals have been established to accomplish this mission, consistent with identified needs and the statutory requirements of the program.

***Goal A: Improve the Understanding of Windstorm Processes and Hazards***

Our current understanding of the detailed characteristics of strong winds near the ground, extreme rainfall hazards, and coastal flooding, which are all critical to understanding and mitigating windstorm risk, is very limited. Goal A focuses on filling these gaps in our knowledge. NWIRP research directions and needs, include improved measurement and modeling of hurricanes, tornadoes, thunderstorms, and other windstorms, enabling a better understanding of the effects of extreme winds and rainfall, and wind-driven storm surge and waves on civil infrastructure and lifelines in the larger context of community resilience. Tools for windstorm hazard assessment need to be developed, including consideration of long term trends in windstorm frequency, intensity, and location, and how changes in these storm characteristics affect risk.

***Goal B: Improve the Understanding of Windstorm Impacts on Communities***

NWIRP needs to support basic and applied research to advance the scientific and engineering knowledge of wind and windstorm-induced impacts. The efforts under Goal B, informed by the results of Goal A, support increased windstorm resilience by nurturing the development of innovative and cost-effective approaches and products to improve the performance of buildings, lifelines, and other structures. Research directions include building a deeper understanding of physical effects of windstorm hazards on buildings and infrastructure as well as the social, cultural, behavioral, and economic factors influencing windstorm impacts and the adoption of

windstorm impact mitigation, supported by enhanced post-storm data collection. New computational tools will be developed for modeling interaction between wind and storm surge hazards and the built environment and for risk assessment and loss estimation.

***Goal C: Improve the Windstorm Resilience of Communities Nationwide***

The results from research and development activities of Goals A and B provide a solid foundation for the application and implementation of the windstorm impact reduction objectives of Goal C. NWIRP will support development of cost-effective windstorm-resistant materials and systems for use in new construction and retrofit of existing construction and development of more windstorm-resilient building codes and standards. NWIRP will also support development and implementation of improved windstorm forecasting methods to increase accuracy and warning time. There is a strong need to integrate results of research on societal response, hazard vulnerability and mitigation, disaster preparedness, emergency response, and disaster recovery into the implementation activities that support hazard mitigation. Accordingly, NWIRP encourages integration of social science research findings into the implementation activities of Goal C, and to increase public awareness of windstorm risks and to promote hazard mitigation policies and programs, as well as improved windstorm readiness, emergency communications and response.

**Federal Coordination Following Tornadoes and Hurricanes**

As lead agency for NWIRP, NIST coordinates post windstorm investigations with the other NWIRP program agencies, NOAA, FEMA, and NSF. The two most recent post windstorm investigations are the 2011 Joplin, Missouri tornado (completed in 2014) and the ongoing investigation of 2017's Hurricane Maria in Puerto Rico.

***NIST Joplin Tornado Investigation***

The Joplin tornado caused 161 fatalities and more than 1,000 injuries, making it the deadliest single tornado on record since the official U.S. records began in 1950. It was a record tornado that occurred in a year of record U.S. tornado activity and impacts. The Joplin tornado's high death toll occurred despite an official tornado warning time of about 17 minutes, greater than the National Weather Service (NWS) national average warning time of approximately 14 minutes.

NIST conducted a multi-year investigation into the wind environment and technical conditions associated with fatalities and injuries, the performance of emergency communications systems and public response, and the performance of residential, commercial, and critical buildings[7]. The investigation led to the development of 16 recommendations, including development of tornado hazard maps for use in engineering design of buildings and infrastructure. Prior to the NIST Joplin investigation, consideration of explicitly designing for the tornado hazard was virtually non-existent. Now, this concept is being actively discussed amongst a wide stakeholder constituency and is under consideration for incorporation into the American Society of Civil

[7] https://nvlpubs.nist.gov/nistpubs/NCSTAR/NIST.NCSTAR.3.pdf

Engineers (ASCE) Standard 7-22 – Minimum Design Loads and Associated Criteria for Buildings and Other Structures.

Interagency NWIRP coordination played a direct role in the implementation of Joplin investigation recommendations. A team member from the National Oceanic and Atmospheric Administration (NOAA) National Severe Storms Laboratory (NSSL) served on the NIST investigative team, facilitating the implementation of another recommendation from the NIST Joplin report,

> *"NIST recommends that technology be developed to provide tornado threat information to emergency managers, policy officials, and the media on a spatially resolved real-time basis to supplement the currently deployed official binary warn/no warn system."*

Specifically, NOAA used this recommendation as additional support for its new weather warning concept, FACETs (Forecasting a Continuum of Environmental Threats), potentially shifting the National Weather Service (NWS) from (primarily) teletype-era, deterministic watch–warning products to high-resolution, probabilistic hazard information (PHI) spanning periods from days (and longer) to within minutes of high-impact weather and water events.[8]

Additionally, NIST coordinated with FEMA by sharing NIST preliminary observations of the damage in advance of FEMA's deployment to Joplin, Missouri under their Mitigation Assessment Team (MAT) Program.

***NIST Hurricane Maria Program***

NIST is currently investigating the effects of Hurricane Maria in Puerto Rico.[9] On September 20, 2017, Hurricane Maria made landfall in Puerto Rico, damaging infrastructure that its communities relied on for medical care, safety, mobility, communications, and more. To better understand how the buildings and infrastructure failed, and how we can prevent such failures in the future, NIST began to study how critical buildings and infrastructure systems performed during the storm.

NIST deployed several disaster experts to Puerto Rico in December 2017 with expertise spanning structural engineering, sociology, emergency communications, and IT support. One of the NIST experts was embedded within a FEMA Mitigation Assessment Team (MAT) that was conducting similar preliminary reconnaissance of the damage caused by Hurricane Maria. This pre-planned coordination with FEMA allowed for both agencies to share information and cover a wider range of reconnaissance activities. The NIST embedded team member also served as an author on the subsequent FEMA MAT report for Hurricanes Maria and Irma.[10]

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[8] https://journals.ametsoc.org/doi/full/10.1175/BAMS-D-16-0100.1

[9] A public announcement of the Hurricane Maria study can be found at: https://www.nist.gov/news-events/news/2018/05/nist-launches-study-hurricane-marias-impact-puerto-rico

[10] https://www.fema.gov/media-library/assets/documents/173789

The NIST Hurricane Maria Program seeks to understand Hurricane Maria's multi-hazard impacts (i.e., wind, rainfall, flooding, landslides, storm surge) and the conditions that led to injuries and deaths; how critical buildings and designated safe areas within them performed—including their dependence on electricity, water, transportation, and other infrastructure; how emergency communications systems performed and the public's response to such communications; and the impacts to, and recovery of, selected businesses, hospitals and schools, as well as the critical social functions they provide.

As with the Joplin tornado investigation, NWIRP coordination figures prominently in the Hurricane Maria Program. In collaboration with the University of Florida (UF), wind tunnel testing of various sites in Puerto Rico where critical buildings experienced significant damage from Hurricane Maria is being conducted using the NSF Natural Hazards and Engineering Research Infrastructure (NHERI) sponsored facility at UF – a signature example of NWIRP post windstorm coordination activity.

Additional NWIRP coordination on Hurricane Maria includes the NSF investment in 34 Rapid Response Projects (RAPID) to gather ephemeral data following the storm and conduct basic research. The outcomes of the RAPID NSF Hurricane Maria projects are being shared with the wider research community, serving as an important source of additional information for the NIST Hurricane Maria Program, and other similar research efforts aimed at reducing hurricane impacts in the United States.

After completion of the Hurricane Maria study, NIST will pursue and track implementation of its recommendations in an effort to reduce windstorm impacts Nationwide.

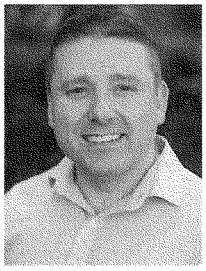
**Conclusion**

NWIRP continues to make strides in implementing the strategy put forth in its strategic plan. However, as losses continue to mount, there is much work to be done. NWIRP stands ready to engage with Congress to strengthen this vital program.

We greatly appreciate the efforts of the members of these committees and other members of Congress to support resilience programs that keep the Nation safe.

I am pleased to answer any questions you may have.

Dr. Scott J. Weaver



Scott J. Weaver is Director of the National Windstorm Impact Reduction Program (NWIRP) in the Engineering Laboratory at the National Institute of Standards and Technology (NIST). NWIRP is a federal interagency science-based program focused on achieving major measurable reductions in the losses of life and property from windstorms, by leveraging the latest science and best practices from across the federal government, academia, and the private sector. Dr. Weaver also holds an appointment as Adjunct Associate Professor in the Department of Atmospheric and Oceanic Science at the University of Maryland.

Prior to joining NIST in 2018, Dr. Weaver served as the Senior Climate Scientist for Environmental Defense Fund where he was engaged in scientific research and outreach at the intersection of meteorology, climate science, and international climate policy. Dr. Weaver also spent several years as a Research Meteorologist in the Climate Prediction Center at the National Oceanic and Atmospheric Administration (NOAA), where his scientific research activities led to improved understanding of the climatic context for extreme weather events (e.g., droughts, floods, heat waves, and tornadoes), and the deployment of this information to inform the development of prediction products, peer reviewed journal publications, scientific assessments, conference proceedings, outreach activities, and educational applications. After receiving a B.S. in Meteorology from Rutgers University, and an M.S. and Ph.D. in Atmospheric and Oceanic Science from the University of Maryland, Dr. Weaver conducted postdoctoral research at the Global Modeling and Assimilation Office of the National Aeronautics and Space Administration (NASA), where his research focused on elucidating the physical mechanisms that link global scale climate variability and change to the regional expression of warm season droughts and floods over the U.S.

Dr. Weaver currently chairs the NWIRP Windstorm Working Group, a federal interagency partnership that carries out coordination and implementation of the NWIRP program. He is also a member of the American Meteorological Society and American Geophysical Union, and has served on numerous panels and working groups, including the interagency Climate Change and Water Working Group, The U.S. CLIVAR Prediction Predictability Applications Interface, NOAA's Drought Task Force, NOAA's Climate Prediction Task Force, and the climate.gov Science Review Board. From 2011 - 2014 Dr. Weaver was an editor for the American Meteorological Society's annual State of the Climate report. Dr. Weaver also serves as a research mentor for undergraduate and graduate students through various federal science and academic research programs.

Dr. Weaver was awarded the Presidential Early Career Award for Scientists and Engineers (PECASE) in 2012, for innovative research at the frontiers of science and technology.

**Education**

Ph.D., Atmospheric and Oceanic Science, University of Maryland

M.S., Atmospheric and Oceanic Science, University of Maryland

B.S., Meteorology, Rutgers University

**TESTIMONY OF MAJOR GENERAL LEE TAFANELLI, KANSAS ADJUTANT GENERAL, DIRECTOR OF KANSAS HOMELAND SECURITY, AND DIRECTOR OF KANSAS EMERGENCY MANAGEMENT**

General TAFANELLI. Thank you, Chairwoman Johnson, Chairwoman Stevens, Chairwoman Fletcher, Ranking Members Lucas, Baird, Marshall, distinguished Members of the Committee, for the opportunity to sit before you today. I'm honored to testify on behalf of Kansas as the Adjutant General, and Director of Kansas' Division of Emergency Management and Kansas Homeland Security.

A 2018 study by the National Institute of Building Sciences found that mitigation can save $6 in future disaster cost for every dollar spent. Kansas saves more money on average than any other State using the Federal Hazard Mitigation Assistance Program, as reported by a recent Pew Charitable Trust study. The data analysis showed that Kansas avoided $6.81 in potential disaster recovery costs for every dollar spent. This return on investment is attributed to the emphasis placed on reducing impacts from the two greatest hazards in Kansas, flooding and windstorms.

With limited resources to contribute to disaster loss reduction, Kansas invests predominantly in the mitigation of flooding and windstorms. To date, Kansas has implemented approximately $220 million in mitigation projects, netting an estimated $1.5 billion in disaster cost avoidance. Over the past 2 decades Kansas has experienced 37 federally declared Presidential disasters, with over 90 percent of them coming of windstorm damages. With funding primarily received through the Post-Disaster Hazard Mitigation Grant Program, Kansas has completed 235 tornado safe rooms, with nearly 95 percent of those installed in schools. The largest cost burden of mitigation within Kansas is by local governments. The successful completion of the aforementioned school safe rooms was greatly influenced by the *American Recovery and Reinvestment Act* in qualified school construction bond programs, which supported the financing of tornado safe rooms in Kansas schools.

Kansas approaches all hazard emergency management planning with a whole community approach. Leading mitigation efforts within Kansas is a Kansas Hazard Mitigation Team consisting of local, State, and Federal partners who provide input into the State's mitigation program, plans, and investment strategies. The use of Kansas Hazard Mitigation Team promotes collaboration of varying mitigation programs through all levels of government. This collaborative approach initiated the development and successful implementation of regional mitigation plans. Twelve regional mitigation plans enabled 105 counties to successfully apply for and use Federal mitigation assistance to reduce loss. This planning approach has been identified by FEMA as a best practice due to effectiveness and cost efficiency.

Our whole community planning approach is vital to understanding and addressing program mitigation challenges. Kansas is a home rule State, and as such, the responsibility for adoption and enforcement of building codes lies with local jurisdictions. Several cities and county jurisdictions, mostly urban communities, have adopted the International Residential Code and the International Building Code, however there are numerous rural jurisdictions

within Kansas without adopted building code. The education and promotion of code adoption remains an ongoing mitigation effort within Kansas, which is why community involvement is of the utmost importance.

Collaboration with other State governments is common, and often involves a sharing of program initiatives and best practices. Our regional mitigation planning approach has been explored by other State programs. Kansas is currently examining implementation of a residential safe room program similar to that in Oklahoma. This program would provide rebates for Kansas residents to install qualified safe rooms on private property, further providing the State's windstorm resilience. Collaboration with the Federal Government is primarily through FEMA, which supports all hazards emergency preparedness, and supports mitigation and recovery. Funding provided by Emergency Management Grant Program is critical to supporting Kansas and its disaster preparedness initiatives.

Additionally, our mitigation programs completely rely on FEMA hazard mitigation funding. Besides supporting emergency management through funding of preparedness activities and cost-share recovery, FEMA provides assistance largely in the form of planning technical assistance training, response resources, post-disaster assessments. FEMA's Hazus program is a notable technical assistance tool that provides a model for estimating potential losses from earthquakes and floods, increasing hazard awareness and planning. However, the absence of tornado-centric models create a significant planning gap that hinders risk-informed windstorm decisions.

Several Federal agencies supporting emergency management efforts through Kansas, including the United States Corps of Engineers, National Oceanic and Atmospheric Administration, among others. The successful implementation of cost-effective mitigation within Kansas is based on local government involvement, Federal funding assistance, and prioritizing projects focused on mitigating against the State's greatest hazards of flooding and windstorms. Efforts undertaken by the National Windstorm Impact Reduction Office supporting our program mitigation approach by allowing data-informed decisionmaking, ultimately improving Kansas' resilience.

The Kansas program will remain committed to reducing disaster loss, and are comforted that the Federal Government continues support of these efforts. Thank you again for the opportunity, and I look forward to your questions.

[The prepared statement of General Tafanelli follows:]

**MG Lee Tafanelli**

**The Adjutant General**
**Director of Kansas Division of Emergency Management and Kansas Homeland Security**
**State of Kansas**

**STATEMENT FOR THE RECORD**

**Submitted to the House of Representatives Committee on**

**Science, Space**
**And**
**Technology**

**Subcommittee on Research and Technology**
**Subcommittee on Environment**

**December 4, 2019**

**Calm Before the Storm: Reauthorizing the National Windstorm Impact Reduction Program**

**The Adjutant General's Department**
**2722 SW Topeka Blvd.**
**Topeka, KS 66611**
**785-646-0090**

Thank you, Chairwoman Stevens and Chairwoman Fletcher, and distinguished members of the Committee for the opportunity to sit before you today.

I am honored to testify on behalf of Kansas as the Adjutant General and Director of Kansas Division of Emergency Management and Kansas Homeland Security.

**MITIGATION EFFORTS IN KANSAS**

A 2018 study by the National Institute of Building Sciences[1] found that mitigation can save $6 in future disaster cost for every $1 spent. Kansas saves more money, on average, than any other state using federal Hazard Mitigation Assistance, as reported by a recent Pew Charitable Trusts study[2]. The data analysis showed that Kansas avoided $6.81 in potential disaster recovery costs for every $1 spent. This return on investment is attributed to the emphasis placed on reducing impacts from the two greatest hazards in Kansas: flooding and windstorms.

With limited resources to contribute to disaster loss reduction, Kansas invests predominately in the mitigation of flooding and windstorms. To date, Kansas has implemented approximately $220 million in mitigation projects, netting an estimated $1.5 billion in disaster cost avoidance. Over the past two decades, Kansas has experienced 37 federally declared presidential disasters with over 90% of them consisting of windstorm damages. With funding primarily received through the post-disaster Hazard Mitigation Grant Program, Kansas has completed 235 tornado safe rooms with nearly 95% of those installed in schools.

The largest cost burden of mitigation within Kansas is by local governments. The successful completion of the aforementioned school safe rooms was greatly influenced by the American Recovery and Reinvestment Act and Qualified School Construction Bond Program which supported the financing of tornado safe rooms in Kansas schools.

**PLANNING AND COLLABORATION**

Kansas approaches all-hazard emergency management planning with a whole-community approach. Leading mitigation efforts within Kansas is the Kansas Hazard Mitigation Team consisting of local, state, and federal partners that provide input into the states mitigation program, plans and investment strategies. The use of the Kansas Hazard Mitigation Team promotes collaboration of varying mitigation programs through all levels of government. This collaborative approach initiated the development and successful implementation of regional mitigation plans. Twelve regional mitigation plans enable 105 counties to successfully apply for and use federal mitigation assistance to reduce loss. This planning approach has been identified by Federal Emergency Management Agency as a best practice due to effectiveness and cost efficiency.

Our whole-community planning approach is vital to understanding and addressing program mitigation challenges. Kansas is a home rule state and, as such, the responsibility for adoption

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[1] https://www.nibs.org/page/mitigationsaves

[2] https://www.pewtrusts.org/en/research-and-analysis/articles/2019/06/17/data-highlight-state-by-state-benefits-of-federal-natural-disaster-mitigation-grants

and enforcement of building codes lies with local jurisdictions. Several city and county jurisdictions, mostly urban communities, have adopted the International Residential Code and the International Building Code. However there are numerous rural jurisdictions within Kansas without an adopted building code. The education and promotion of code adoption remains an on-going mitigation effort within Kansas which is why community involvement is of the utmost importance.

Collaboration with other state governments is common and often involves the sharing of program initiatives and best practices. Our regional mitigation planning approach has been explored by other state programs. Kansas is currently examining the implementation of a residential safe room program similar to Oklahoma. This program would provide rebates for Kansas residents to install qualified safe rooms on private property, further improving the state's windstorm resilience.

Collaboration with the federal government is primarily through FEMA, which supports all-hazard emergency management preparedness, mitigation, and recovery. Funding provided by the Emergency Management Grant Program is critical to supporting the Kansas Emergency Management Program and disaster preparedness initiatives. Additionally, our mitigation program is completely reliant on FEMA Hazard Mitigation Assistance funding. Besides supporting emergency management through funding of preparedness activities and cost-shared recovery, FEMA provides assistance largely in the form of planning technical assistance, training, response resources, and post-disaster assessments. FEMA's Hazus program is a notable technical assistance tool that provides a model for estimating potential losses from earthquakes and floods increasing hazard awareness and planning. However, the absence of a tornado-centric model creates a significant planning gap that hinders risk-informed windstorm decisions within Kansas.

Several federal agencies support emergency management efforts within Kansas including the United States Corps of Engineers and National Oceanic and Atmospheric Administration among others. NOAA and the National Weather Service support the forecasting and warning of severe weather and serve as an emergency support function partner within the State Emergency Operations Center. The National Weather Service is instrumental in our program's preparedness and response to natural disasters.

**CONCLUSION**

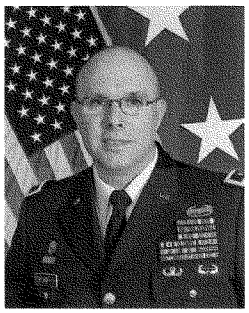
The successful implementation of cost-effective mitigation within Kansas is based on local government involvement, federal funding assistance, and prioritizing projects focused on mitigating against the state's greatest hazards of flooding and windstorms. Efforts undertaken by the National Windstorm Impact Reduction Office support our program mitigation approach by allowing data-informed decision making, ultimately improving Kansas resilience. Building code research performed to date has been successful in reducing impacts of windstorms within Kansas. However, there remains the need to examine ways to improve the implementation of this research within communities. The Kansas program will remain committed to reducing disaster loss and are comforted that the federal government continues support of these efforts.

Thank you again for the opportunity, and I look forward to your questions.

# BIOGRAPHY

## THE ADJUTANT GENERAL OF KANSAS

### MAJOR GENERAL LEE E. TAFANELLI



Major General Lee E. Tafanelli was appointed The Adjutant General of Kansas on 8 January 2011.

As The Adjutant General, he oversees the activities of the Adjutant General's Department providing personnel administration and training guidance for over 7,000 soldiers and airmen in the Kansas Army and Air National Guard as well as leadership to the full-time National Guard and State employees of the Adjutant General's Department. He directs the Kansas Division of Emergency Management responsible for leading a core group of professionals tasked with preparing for and responding to emergency situations within the state of Kansas. This includes guidance and training to 105 county emergency managers and their staffs. As the Kansas Director of Homeland Security, Major General Tafanelli ensures security in the state is a top priority.

During his career in the Kansas Army National Guard, Major General Tafanelli has commanded at the Company, Battalion, Brigade, and State level with additional assignments in personnel, logistics, finance, mobilization readiness, and operations. During OPERATION IRAQI FREEDOM III, Major General Tafanelli commanded the 891st Combat Engineer Battalion in Iraq.

Prior to his appointment as Adjutant General, Major General Tafanelli was assigned as the Assistant Adjutant General and Commander, Land Component, Kansas Army National Guard. In addition, he served in the Kansas House of Representatives representing the 47th district from 2001-2011.

Major General Tafanelli received his commission from Pittsburg State University, Army Reserve Officer Training Corps on 17 December 1982 and holds master's degrees from Kansas State University and the Army War College.

**TESTIMONY OF DR. DELONG ZUO,**
**ASSOCIATE PROFESSOR OF CIVIL ENGINEERING,**
**NATIONAL WIND INSTITUTE, TEXAS TECH UNIVERSITY**

Dr. ZUO. Good afternoon, Chairwoman Johnson, Ranking Member Lucas, Chairwoman Fletcher, Ranking Member Marshall, Chairwoman Stevens, Ranking Member Baird, and Members of the Subcommittees. I'm an Associate Professor of Civil Engineering at Texas Tech University. I'm also the Technical Director of the Wind Engineering Pillar of the National Wind Institute at Texas Tech University. I'm very pleased to be here today to address you on behalf of my University.

With a student body of 37,000, Texas Tech University's main campus is located in the city of Lubbock, which is one of the fastest-growing communities in the State of Texas. The National Wind Institute at Texas Tech University has its roots following the 1970 Lubbock Tornado. Over the years it has grown into an educational and a research enterprise that supports convergent research in atmospheric measurement and simulation, wind engineering, and energy systems. Today the Institute has more than 40 faculty affiliates from across the University campus, and it maintains a suite of state-of-the-art research facilities. It also hosts a one-of-its-kind Wind Science Engineering Ph.D. program, which trains students, and prepares them to answer today's and tomorrow's challenging questions. With contributions from the National Wind Institute and elsewhere, the National Windstorm Impact Reduction Program has enabled many advancements, with the potential to enhance the resilience of communities to wind hazards.

Despite the progress, however, severe windstorms remain among the most destructive and most costly natural hazards. As shown by Hurricanes Katrina, Sandy, Maria, and the Joplin and Moore tornadoes, windstorms leave behind long trails of destruction, with a large number of fatalities, and traumatic effects that often take communities years to recover from. Further underscoring these challenges are statistics that show losses caused by windstorms have been continuing to grow, without any apparent sign of slowing down. We believe that Congress can consider five non-trivial changes to the National Windstorm Impact Reduction Program that will further support its mission to reduce windstorm impacts.

First, NWIRP can forge the closer connections between atmospheric science and engineering communities, through support for targeted research campaigns, for the express purpose of obtaining atmospheric measurements for engineering applications. Second, the program can also encourage closer connections to the social science community. That translates atmospheric and engineering research outcomes for social and economic applications. For example, underprivileged communities, that is people who live in mobile homes, are particularly vulnerable to windstorms. However, they're also often the least likely to benefit from advancements in scientific and wind hazard research.

Third, the NSF sponsorship of shared use experimental facilities, so that every program can be expanded to support a dedicated experimental facility for tornado hazard research. Such an expansion would build on the success of existing NHERI-sponsored facilities for other types of hazards, who are providing a unique testing plat-

form that contributes to the urgent need associated with the lack of codes and standards for the design of tornado-resistant buildings. Fourth, NSF can improve the rapid response research mechanism that can accommodate unique challenges associated with windstorms. The current mechanism under NSF's existing RAPID (Rapid Response Research) program is largely reactive in nature, and time scale for application and award approval does not lend itself to the important field studies of transient and unpredictable windstorm events. Finally, NWIRP can improve the adoption of contemporary and emerging technologies, such as machine learning, that leverages the enormous volume and diversity of data associated with wind hazards, and additive manufacturing to radically change materials and methods used in the construction industry.

In closing, we very much appreciate the longstanding commitment by Congress and the Federal agencies to strengthen the Nation's ability to resist windstorms. Texas Tech University looks forward to continuing our leadership role in research and education that supports this critical mission, as Congress and the agencies seek to improve this critical program. Thank you again for holding this important hearing, and the opportunity to share our perspectives. I look forward to answering your questions.

[The prepared statement of Dr. Zuo follows:]

TEXAS TECH UNIVERSITY
National Wind Institute™

Good afternoon Chairwoman Fletcher, Ranking Member Marshall, Chairwoman Stevens, Ranking Member Baird, and members of the subcommittees. I am an Associate Professor of Civil Engineering and the Technical Director of the Wind Engineering Pillar of the National Wind Institute at Texas Tech University. I am very pleased to address you today on behalf of my University.

First, allow me to briefly introduce Texas Tech University and its National Wind Institute. With a student body of 37,000, Texas Tech University's main campus is in the city of Lubbock, which is one of the fastest growing communities in the State of Texas. Among its many recognitions, Texas Tech is one of the 131 universities and colleges in the Carnegie Classification of Institutions of Higher Education's "Very High Research Activity" category. The aspiration of the University is to provide the highest standards of excellence in higher education, foster intellectual and personal development, and stimulate meaningful research and service to humankind.

The National Wind Institute at Texas Tech University has its roots in a research effort following the 1970 Lubbock Tornado. Over the years, it has grown into an educational and research enterprise that supports convergent research in atmospheric measurement and simulation, wind engineering, and energy systems. Today, the Institute has more than 40 faculty affiliates from the College of Arts and Sciences, the Whitacre College of Engineering and the Rawls College of Business at Texas Tech University. It also hosts a one-of-its-kind multidisciplinary Wind Science and Engineering Ph.D. program which trains students and prepares them to answer today's and tomorrow's challenging questions.

To support faculty and students, the Institute maintains a suite of state-of-the-art research facilities and a technical and administrative staff to enable successful execution of large and complex research projects. The wind engineering research pillar of the Institute, in particular, utilizes unique facilities for the understanding of windstorms and their impact. These include the largest tornado simulator in the United States, which can simulate tornado-like winds and accommodate research of tornado effects on buildings and other structures, a StickNet platform that can be rapidly deployed to measure near-ground wind speeds, pressures and temperatures in windstorms, and two mobile Ka-band radars that can remotely measure wind speeds in severe storms.

In the investigation following the 1970 Lubbock tornado and continuing to the present, the National Wind Institute has promoted a multidisciplinary approach that has produced significant outcomes for the wind hazards research community and decisionmakers. One of the more widely known historical examples is the Enhanced Fujita (EF) scale that is commonly used to rate the strength of tornadoes. Today, the Institute serves as a hub for researchers from atmospheric science, geography, civil engineering, mechanical engineering, computer science and business. It encourages and fosters forward, out-of-box thinking and embraces change, especially those introduced by new technologies. This approach has allowed the Institute to develop convergent research initiatives aimed at transformative advancements in windstorm impact reduction. When the need arises, the Institute has also proactively formed teams with strategic partners to generate impacts that cannot be achieved independently. For example, the Institute recently joined forces

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with the Wall of Wind Experimental Facility at Florida International University to establish a Wind Hazard Infrastructure Performance Center under NSF's Industry–University Cooperative Research Centers (IUCRC) Program with a goal to directly address the needs of the industry in the quest to improve the performance of the infrastructure in wind hazards. With the capabilities enabled by its rich tradition, unique research infrastructure and the multidisciplinary teams of faculty and students, the National Wind Institute at Texas Tech University continues to be at the forefront of the endeavor to answer the grand challenges posed by windstorms.

With contributions from the National Wind Institute and elsewhere, the National Windstorm Impact Reduction Program has enabled many advancements with the potential to significantly enhance the resilience of communities to wind hazards. For example, advancements in atmospheric science have resulted in improved tornado forecasting and hurricane path prediction; better understanding of wind effects have allowed more accurate assessments of structural performance in windstorms; the utilization of modern platforms such as drones and satellites have dramatically enhanced the capability of post disaster damage surveys; and the increasing emphasis in social studies has highlighted the socioeconomic impacts of windstorms, such as the particular vulnerabilities of underprivileged populations.

Despite the advancements, however, severe windstorms remain among the most destructive and costly natural hazards. As shown by hurricanes Katrina (2005), Sandy (2012) and Maria (2017) and the Joplin (2011) and Moore (2013) tornadoes, windstorms leave behind long trails of destruction with a large number of fatalities and traumatic effects that often take affected communities years to recover from. Further underscoring these challenges are statistics that show losses caused by windstorms have been continuing to increase without any apparent sign of slowing down. While many factors have been cited as the reasons for the persistent devastations by windstorms, we believe that Congress can consider non-trivial changes to the National Windstorm Impact Reduction Program that will further support its mission to reduce windstorm impact:

1) **Closer Connections Between Atmospheric Science and Engineering Communities.** Under the National Windstorm Impact Reduction Program, substantial resources have been allocated to the atmospheric science community to study windstorms, and to the engineering community to study the effects of windstorms on civil infrastructure. However, despite the multi-faceted nature of the problems involved, most of these studies are performed within the boundaries of the disciplines, which has limited their potential impacts. In particular, there have been significant investments in tornado measurement, modeling, and forecasting. Large federally-funded projects such as VORTEX, VORTEX 2, and VORTEX Southeast are a few examples. However, these projects are all geared towards the understanding of weather systems, and the value of the measurements from these projects is limited in engineering applications due to the lack in measurement resolution. For this reason, although engineers have been using both tornado simulators and numerical methods to simulate tornadoes and their effects on structures, the scientific and practical impact of these simulations are limited without adequate understanding of the

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fundamental aspects of the windstorms they are trying to replicate. This situation can be overcome by providing support for targeted campaigns by joint teams of atmospheric scientists and engineers for the express purpose of obtaining measurements for engineering applications.

2) **Closer Connections to the Social Science Community**. With the advancements in atmospheric science and engineering, we can now forecast windstorms and design wind resistant buildings better than ever before. However, such advancements have not been timely and effectively translated and transitioned into socioeconomic applications which has limited the impacts of the advancements. For example, underprivileged communities, such as people who live in mobile homes, are particularly vulnerable to windstorms. However, these communities are often the least likely to benefit from the advancements in scientific wind hazard research. To overcome these and similar barriers, atmospheric scientists, engineers and social scientists must work together to develop science- and engineering-based policies and solutions that specifically address these needs.

3) **Providing Shared-Use Experimental Facilities for Tornado Hazard Research.** In 2015, NSF established the Natural Hazards Engineering Research Infrastructure (NHERI) program with an estimated funding amount of $62,000,000 over a 5-year period. This Infrastructure has allowed shared usage of major experimental facilities for studies of seismic and wind hazards as well as the secondary hazards caused by earthquake and windstorms, such as tsunamis and storm surges. It has greatly benefited the hazard research community by enabling investigations that were difficult or infeasible in the past. For example, thanks to NHERI, researchers from any university in the United States now have access to two large wind tunnels, one at the University of Florida, and the other at Florida International University, for experiments that are otherwise impossible at most institutions. In addition, the Cyber Infrastructure of NHERI, which is hosted at the University of Texas at Austin, provides a platform for the hazard research community to share and create data and methods in a timely and organized manner. All of these assets in NHERI have and will continue to contribute to the reduction of hazard impacts that will soon be felt by society.

However, NHERI currently does not have any experimental facility for tornado hazard research, despite the fact that tornadoes are one of the two most deadly and costly types of windstorm (the other type being hurricanes). According to National Oceanic and Atmospheric Administration's (NOAA) Storm Events Database, tornadoes have caused nearly 900 fatalities and more than $19 billion in property damage in the United States over the past decade alone. There is a need for a NHERI tornado hazard research facility since most buildings and structures are currently not designed for tornadoes because codes and standards for tornado resistant design are still not available. A number of facilities, including some at Texas Tech University, are good candidates for meeting this need. For example, the tornado simulator at Texas Tech University and Iowa State University can be used for the study of tornado-induced loads on buildings. With the mandate by NSF that data generated at NHERI experimental facilities be hosted at the NHERI Cyber

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Infrastructure for public access, we believe that the inclusion of tornado hazard experimental facilities for shared usage can accelerate the study of tornadoes and their effects while significantly reducing impacts.

4) **Improving Rapid Response Research Mechanisms.** Rapid response research allows the study of natural hazards while they are happening or in their immediate aftermath. Currently, the primary mechanism that supports rapid response research is the NSF RAPID program, which has been significantly strengthened with the recent establishment of the RAPID facility in NHERI. While RAPID has been successful in enabling research that provides insight into the nature of the natural hazards and their impacts, this program can be improved to better serve its intended purposes. In particular, the current funding mechanism of the RAPID program is mostly reactive in nature and the application process often prohibits the collection of data, such as measurements of windstorms and the damages and trauma they inflict in a truly urgent manner. For example, researchers cannot make measurements in advance, or during a day-long transient windstorm event such as a hurricane, through a mechanism that requires an application to NSF, waiting weeks for a decision, and then heading to a site to conduct research. Only with a more proactive approach can the RAPID program facilitate more timely and effective acquisition of field measurements, whether they be for science, engineering or social studies.

5) **Improving the Adoption of Contemporary and Emerging Technologies:** While researchers using conventional approaches have historically helped reduce the impact of windstorms, most of the past contributions have been incremental in nature. By contrast, many contemporary and emerging technologies have the potential to transform wind hazard research and fundamentally change windstorm resilience. For example, today's research related to windstorms and their impacts through field measurements, wind tunnel testing, or post disaster damage surveys routinely generate tremendous amounts of data that cannot be fully utilized using traditional methods. New and rapidly improving data science and machine learning technologies can provide the perfect tools for maximizing and leveraging this valuable data and enable transformative discoveries. This is especially true when different forms of data, such as images, numbers and social media texts need to be analyzed collectively in studies that cross the boundaries of traditional disciplines. As another example, with the rapidly emerging additive manufacturing technology, entire buildings can be constructed through 3D printing. It is possible that in the not-so-distant future, this technology will be used routinely in the construction industry. The effects of this breakthrough in construction technology can be monumental, as it can introduce brand-new forms of buildings and other structures as well as brand-new construction materials that are structurally different from conventional materials such as steel, concrete, and wood. All this can fundamentally change the impacts of windstorms on the built environment.

In closing, we very much appreciate the longstanding commitment by Congress and the federal agencies involved in NWIRP to strengthen the United States' ability to increase resilience to wind

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hazards. Texas Tech University believes that with support from Congress, all these changes can be implemented by the National Windstorm Impact Reduction Program. The University is also confident that the institutional capacity and partnerships built across the Nation through the National Windstorm Impact Reduction Program will fundamentally transform windstorm resilience.

I would like to conclude by thanking you for inviting me to this hearing. I am proud to have this opportunity to share with you Texas Tech University's vision for wind hazard impact reduction, our capabilities in responding to these challenges, and serving as a resource for the subcommittees. I look forward to answering your questions.

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**Delong Zuo, Ph.D.**
Associate Professor of Civil Engineering
Texas Tech University

Dr. Delong Zuo is an Associate Professor in the Department of Civil, Environmental and Construction Engineering at Texas Tech University. He is also the Technical Director of the Wind Engineering Pillar of the National Wind Institute at Texas Tech University. His expertise is in the areas of structural dynamics, wind engineering, and wind hazard mitigation. He utilizes both experimental and analytical-numerical approaches to understand and simulated wind and, on this basis, to study the effects of wind on structures. Dr. Zuo has conducted research sponsored by both Federal and State agencies as well as the private industry. His current research focuses on the assessment of tornadic loading on buildings and wind-induced vibration of slender structures such as long-span bridges and towers of various types.

Dr. Zuo is currently the Principle Investigator of the Wind Hazard and Infrastructure Performance Center under the Industry–University Cooperative Research Centers Program of the National Science Foundation. He also serves as a member of the Strategic Committee of the Network Coordination Office of the Natural Hazards Engineering Research Infrastructure supported by the National Science Foundation.

Dr. Zuo received a B.S. in Civil Engineering from Chongqing Jiaotong University in China in 1996. He was awarded a Ph.D. in Civil Engineering from the Johns Hopkins University in 2005, studying under Professor Nicholas P. Jones.

## TESTIMONY OF MR. RYAN COLKER, VICE PRESIDENT OF INNOVATION, INTERNATIONAL CODE COUNCIL, AND EXECUTIVE DIRECTOR, THE ALLIANCE FOR NATIONAL AND COMMUNITY RESILIENCE

Mr. COLKER. Chairwoman Johnson, Ranking Member Lucas, Chairwomen Fletcher and Stevens, Ranking Members Marshall and Baird, and Members of the Committee, I'm Ryan Colker, Vice President of Innovation at the International Code Council, and Executive Director of the Alliance for National and Community Resilience, or ANCR. It is my honor to testify on the valuable role of Federal agencies in addressing the Nation's windstorm risks. These Federal efforts frequently support the development, adoption, and enforcement of building codes and other mitigation strategies.

The Code Council, with the support and engagement of its 65,000 members from the design, construction, manufacturing, and regulatory sectors, is dedicated to providing safe, sustainable, and resilient buildings and communities. The Code Council develops model building codes, the I-Codes, which are the basis for building regulatory requirements in all 50 States, multiple Federal agencies, and internationally. We also develop standards, including Standard 500 for the design of storm shelters, and Standard 600 for residential construction in high-wind areas.

Building codes are a highly cost-effective hazard mitigation measure. The congressionally established National Institute of Building Sciences found that adopting the 2018 International Building Code and International Residential Code, which governed commercial and residential construction and renovations respectively, provided $10 in mitigation benefits against hurricane winds for every $1 invested. Congress and Federal agencies have recognized the benefits of codes as disaster mitigation strategies through the *Disaster Recovery Reform Act*, bipartisan *Budget Act*, FEMA's strategic plan, and the National Mitigation Investment Strategy. Federal agencies contribute to the content of the code through the translation of research, to code changes that improve criteria, and subsequent code additions, and risk mapping that helps dictate what criteria should apply where. Agencies also support technical assistance to State and local governments, undertaking code updates.

Despite limited funding, NWIRP has made several significant contributions. NWIRP supported FEMA research and publications, led to the development of Standard 500, and the requirement that K through 12 schools, and emergency responder facilities in tornado-prone regions include storm shelters. Notably, there have been no fatalities in properly designed and constructed storm shelters.

Most recently, NIST and NOAA have developed a methodology for measuring tornado wind speed, leading to development of tornado risk maps, and new building design procedures, which will ultimately be incorporated into codes and standards. Additional codes and standards updates proposed by the NWIRP agencies have been successful, including the development of new designed wind speed maps that have been incorporated into the latest I-Codes. Following Hurricane Maria, FEMA, NOAA, and NIST collaborated to

develop updated local wind maps that supported Puerto Rico's code update, based on the latest edition of the I-Codes.

Building off these successes, NWIRP has additional opportunities to help mitigate windstorm risk. Adequate funding, a long-term authorization, and champions in both Congress and the administration are essential. At several NWIRP agencies, funding has lagged significantly below authorized levels, resulting in challenges to the program's effectiveness. For comparison, the National Earthquake Hazard Reduction Program received over $164 million for program activities in FY19, more than 5 times NWIRP's prior authorized levels, while the annualized losses from windstorms are nearly 10 times those from earthquakes.

Additional areas for NWIRP focus include reducing the impacts of windstorms on manufactured housing through formal engagement of HUD (Department of Housing and Urban Development), advancing guidance for the evaluation and retrofit of existing buildings, undertaking research to understand and respond to the changing nature of windstorm risks, creating formal linkages between NWIRP and other hazard programs, building the NWIRP brand, strengthening the connections between NWIRP and private sector codes and standards developers, and increasing economic and social science research supporting codes and standards development and adoption, including benefit cost ratios and hazard communication. This is critical, given that only about a third of the 21 States that regularly face tornado risk require tornado shelters in schools consistent with current codes.

In addition to codes and standards, Federal research supports broader activities that improve national resilience. ANCR, a cooperative effort of the Code Council, U.S. Resiliency Council, and the Meridian Institute, was born out of the recognition that communities are only as resilient as their weakest link. While building codes are a necessary component of a community's resilience strategy, additional policies and procedures must be in place. ANCR is developing a coordinated set of benchmarks for 19 community functions that influence resilience. ANCR's benchmarks on housing and buildings rely on codes and other existing standards, and NWIRP research, to support its activities.

Thank you again for the opportunity to support reauthorization of NWIRP. The Code Council and ANCR will continue to provide communities with the codes, standards, benchmarks, and other tools they need to be safe and resilient. We stand ready to support this Committee, and the NWIRP agencies, in achieving shared goals of better understanding windstorms and assessing and reducing their impacts. Thank you.

[The prepared statement of Mr. Colker follows:]

TESTIMONY TO THE

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEES ON RESEARCH AND TECHNOLOGY AND ENVIRONMENT

"CALM BEFORE THE STORM: REAUTHORIZING THE NATIONAL WINDSTORM IMPACT REDUCTION PROGRAM"

DECEMBER 4, 2019

RYAN M. COLKER, J.D., CAE
VICE PRESIDENT, INNOVATION, INTERNATIONAL CODE COUNCIL
EXECUTIVE DIRECTOR, ALLIANCE FOR NATIONAL & COMMUNITY RESILIENCE

## A Multi-Pronged Approach to Safe and Resilient Buildings and Communities

### *Model Building Codes and the International Code Council*

Safe and resilient buildings and communities rely on a robust, coordinated system to which the International Code Council and the Alliance for National & Community Resilience (ANCR) are important contributors.

The International Code Council is a non-governmental organization, driven by the engagement of 65,000 members, that is dedicated to helping communities and the building industry provide safe, resilient, and sustainable construction through the development and use of model codes (I-Codes) and standards used in design, construction, and compliance processes. All 50 states, federal agencies, and many global markets choose the I-Codes to set the standards for regulating construction and major renovations, plumbing and sanitation, fire prevention, and energy conservation in the built environment.

The Code Council's model building codes are national "voluntary consensus standards" under Office of Management and Budget (OMB) *Circular A-119: Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment*

*Activities* and the *National Technology Transfer Advancement Act* (NTTAA), meaning they are developed in an open forum—with a balance of interests represented and due process—that, ultimately, ensures a consensus outcome. Federal agencies (including the Federal Emergency Management Agency (FEMA), National Institute of Standards and technology (NIST) and the Environmental Protection Agency (EPA)), communities, structural engineers and architects, members of the construction industry, and the fire services are active participants in the code development process, ensuring the final consensus result balances cost, safety, and other public interest considerations.

State and local governments adopt, amend, and enforce model building codes to advance policy goals and to ensure the health, safety, and welfare of their residents. The NTTAA directs federal agencies and departments to adopt voluntary consensus standards wherever possible (avoiding development of unique government standards) and use such standards to carry out activities and policy objectives. This system of code development has provided the citizens of the U.S. the highest level of building safety in the world for more than 80 years.

The I-Codes are widely utilized and supported at the federal, state, and local levels. All 50 states use the International Building Code (IBC) as the basis for commercial and multifamily housing construction and safety regulation. The International Residential Code (IRC) is in use or adopted in 49 states. The General Services Administration (GSA) requires the I-Codes for civilian governmental buildings[1] and the Department of Defense (DOD) requires the IBC and IRC for all U.S. military bases.[2] Federal agencies and federally supported research feature prominently in the code development process, including several provisions governing resilience against wind hazards that the National Windstorm Impact Reduction Program (NWIRP) has supported. The IBC, IRC, and the other I-Codes are updated on a three-year cycle to allow the capture of new research and technologies.

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[1] GSA, *Facilities Standards for Public Buildings Service* ("GSA P-100") (July 2018).
[2] DOD, *Unified Facilities Criteria, DoD Building Code (General Building Requirements)* (Nov. 2018).

The IBC and IRC include numerous provisions to mitigate homes against high wind risk, by requiring:

- Enhanced nailing patterns (more nails and closer spacing) to ensure roof decks (under shingles) are adequately attached to roof trusses;
- Strengthened connections from the roof to walls to the foundation to keep roofs from blowing off, walls from collapsing, or houses from sliding off their foundations;
- Glazing or coverings like shutters for windows, doors, and other openings like garage doors, so that windborne debris and other projectiles cannot break glass or push in the doors, etc., when under pressure from high wind forces;
- Wind resistance for roof coverings (shingles, tile, etc.) and proper installation methods (ring-shank nails or screws); and
- Tornado shelters in new K-12 schools and emergency responder facilities in the most tornado prone areas.[3]

The Code Council has also codeveloped the *ICC/National Storm Shelter Association (NSSA) Standard 500: Standard for the Design and Construction of Storm Shelters* and developed the *ICC Standard 600: Standard for Residential Construction in High-Wind Regions*, which provides prescriptive requirements for the design and construction of residential structures in high-wind regions that go beyond the requirements within the base residential code. Standard 600 is currently being updated in cooperation with the Insurance Institute for Business and Home Safety (IBHS) to address windstorm and other hazards.

In addition to the model codes, the Code Council provides a family of solutions to state and local governments to support their resilience goals. These solutions include training and certification on codes and standards, product testing and evaluation of compliance with codes and standards, accreditation services for product evaluators and resilience benchmarks.

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[3] FLASH. *Why Americans Aren't Concerned About Building Codes (even though they should be)*. June 2019. http://newsroom.flash.org/commentary/why-americans-arent-concerned-about-building-codes-even-though-they-should-be.htm.

***Federal Research in Support of Model Building Codes***

Federal agencies and federally supported research feature prominently in the code development process. Federal contributions through the National Earthquake Hazard Reduction Program (NEHRP) and energy efficiency provisions through the Department of Energy (DOE) are summarized below. Wind hazard-specific activities under NWIRP are described in the Notable Success under NWIRP section.

Like NWIRP, NEHRP brings relevant agencies together to support research and the development of criteria to mitigate a hazard risk—in this case earthquakes. Initially established by the Earthquake Hazards Reduction Act of 1977 (P.L. 95-124), NEHRP has grown into a mature, well-coordinated, robust program. A key component of the Program is the development of the *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures*. The *Provisions* are developed through a consensus process that brings together seismic researchers, structural engineers and other stakeholders to translate the latest findings into design guidance that reduces risk. During this process, additional research needs are identified and brought back to the NEHRP agencies for potential funding. The *Provisions* are used as the primary resource for the professional design standard *ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures*. The 2009 edition of the *Provisions*, FEMA P-750, was largely adopted in ASCE/SEI 7-10. The 2015 edition of the *Provisions*, FEMA P-1050, has been similarly adopted in ASCE/SEI 7-16. ASCE/SEI 7 is incorporated into the International Building Code, the International Residential Code and the International Existing Building Code. Such a process could be effective for the development and implementation of future wind provisions in the I-Codes.

The Code Council also develops the International Energy Conservation Code (IECC), which provides for the energy efficient construction of residential and commercial buildings. The DOE Building Technologies Office (BTO) supports the development and implementation of building energy codes, like the IECC, by providing technical assistance for code development, adoption, and compliance. BTO coordinates with stakeholders to improve model energy codes and

provides technical assistance to states implementing updated energy codes. The purpose of BTO's dedicated Building Energy Codes Program (BCEP) is to "improve building energy efficiency, and to help states achieve maximum savings" by "advancing building codes." BECP, supported by Pacific Northwest National Laboratory, evaluates each new edition of model energy codes to determine energy savings compared to prior versions. This determination triggers a requirement for states to evaluate their current energy code and provide a certification to the DOE Secretary that for commercial buildings they have updated their codes to meet or exceed the updated edition and for residential buildings that they have made a determination as to whether it is appropriate to revise their code to meet or exceed the updated edition.[4] The BECP has also previously proposed code changes to the IECC based on findings from the national labs.

***Solutions to Support Community Resilience Goals***

The Alliance for National & Community Resilience (ANCR), a cooperative effort of the International Code Council, U.S. Resiliency Council and the Meridian Institute, was born out of the recognition that communities are only as resilient as their weakest link. While building codes are a necessary component of a community's resilience strategy, additional policies and procedures must be in place. Communities function as a complex, interconnected system of systems. Individual systems rarely operate in isolation from one another.

ANCR aims to provide the information that communities need to understand and benchmark their current level of resiliency, identify and understand options available to fill gaps and increase resiliency, and to understand the future benefits to be gained by investing in advance of the next hazard event.

ANCR identified 19 community functions that influence community resilience. These functions cut across the social, organizational and infrastructural aspects of communities. The 19 community functions are captured in Figure 1. The Community Resilience Benchmarks (CRB) system will include benchmarks for the 19 community functions and will provide communities

[4] 42 U.S.C. § 6833.

with a coordinated, comprehensive tool to help facilitate decision making. Businesses and people can also utilize the tool to decide where to invest and where to live.

ANCR's first benchmark, released in January 2019, examines building-related activities.[5] The safety, sustainability and resilience of a community's building stock has a direct correlation to the community's overall resilience. The Buildings Benchmark focuses on the regulatory aspects of assuring the safety and resilience of the physical structures. Building code adoption and enforcement feature prominently in the Buildings Benchmark.

Tackling another resilience challenge before communities, ANCR developed its Housing Benchmark to cover policies associated with the availability and affordability of housing and the associated socio-economic factors.[6] The Housing Benchmark clearly establishes the interconnection between housing affordability and availability and the resilience of buildings. Disasters tend to hit low- and moderate-income families the hardest.[7] Policies seeking to promote affordable housing must ensure the creation and preservation of homes that minimize impacts to their residents and their property from natural hazards.

The ANCR benchmarks are being developed by a team of subject matter experts (SMEs) in each of the functional areas. Where practical, the benchmarks utilize existing standards and guidance to support broad applicability and ease of use. ANCR benchmarks rely on research from programs like NWIRP and the codes and standards the research supports to allow consistent and meaningful evaluations. For example, ANCR is currently assembling subject matter experts to complete its next benchmark—the Water Benchmark. The Water Benchmark will examine a community's potable water, waste water and stormwater management infrastructure and practices. Stormwater management practices are captured in building codes and other policies—resources that are developed based on understanding the impacts from windstorms such as hurricanes, thunder storms and derechos.

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[5] https://iccsafe.realmagnet.land/190110-ancr-download
[6] http://media.iccsafe.org/2016_MarComm/16-13282_GR_ANCR_Website/pdf/ANCR_Merged_2.pdf
[7] SAMHSA. Greater Impact: How Disasters Affect People of Low Socioeconomic Status. July 2017.

Through its holistic approach to community resilience and the recognition of fundamental mitigation practices like building codes, ANCR is bringing research and application to the fore in a manageable way.

*Figure 1: ANCR Community Functions*

### The Importance of Addressing Windstorm Risks

Every state is exposed to hazards from one or more windstorm type—tornadoes, tropical cyclones/hurricanes, thunderstorms, nor'easters, winter storms and mountain downslope winds.[8] From 1980 through 2017, windstorms caused over $1 trillion in economic losses and

[8] NWIRP. Strategic Plan for the National Windstorm Impact Reduction Program. September 2018. https://www.nist.gov/system/files/documents/2018/09/24/nwirp_strategic_plan.pdf.

caused over 5,000 fatalities. In 2018 alone, wind-related storms caused approximately $65 billion in damage and 142 deaths.[9]

Over the last ten years tornadoes impacted an average of 23 schools annually. Wind and flood events represent the greatest number of Presidential disaster declarations.[10]

***Tropical Storms and Hurricanes***

Hurricanes primarily impact states along the Atlantic Ocean and Gulf of Mexico as well as Hawaii and territories in the Caribbean and the Pacific. Recent hurricanes and tropical storms including Harvey ($125 billion estimated damage), Maria ($90 billion), Irma ($50 billion),

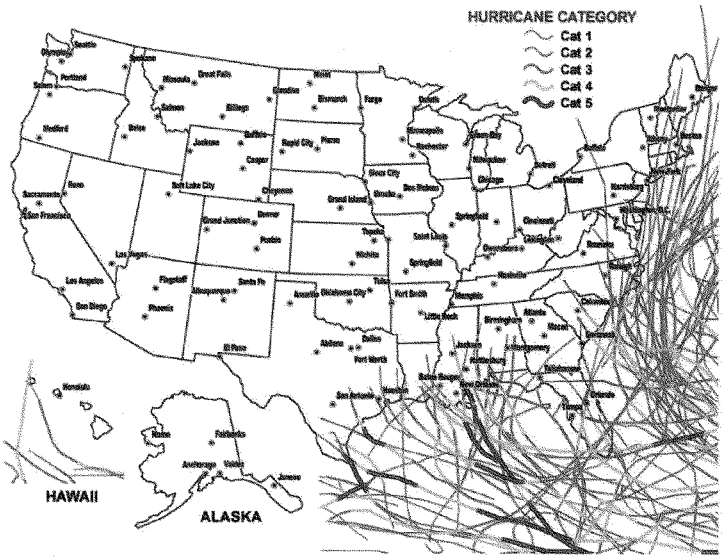


*Figure 2: Hurricane tracks from 1950 to 2014 mapped by intensity (NWIRP Strategic Plan)*

[9] https://www.ncdc.noaa.gov/billions/overview
[10] Congressional Research Service. Stafford Act Declarations 1953-2016: Trends, Analyses, and Implications for Congress. August 28, 2017.

Michael ($25 billion), Sandy ($70 billion) and Katrina ($150 billion and over 1,200 fatalities) have been embedded into the American story.[11]

***Tornadoes and Thunderstorms***

While tornadoes are possible in every state, the vast majority have been concentrated from the Continental Divide to the east coast. Over the last ten years, tornadoes have caused an average loss of over $10 billion per year. According to Property Claim Services (PCS®), tornadoes accounted for 40 percent of inflation-adjusted insured catastrophe losses from 1997 to 2016. In 2018 insured losses from U.S. tornadoes and thunderstorms totaled $14.1 billion, down from

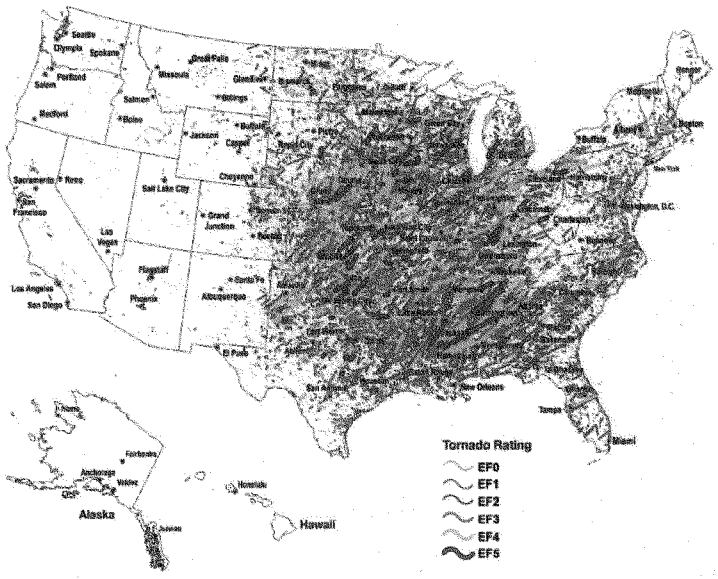


*Figure 3: Tornado tracks from 1950 to 2014 mapped by intensity (NWIRP Strategic Plan)*

[11] NWIRP. Strategic Plan for the National Windstorm Impact Reduction Program. September 2018. https://www.nist.gov/system/files/documents/2018/09/24/nwirp_strategic_plan.pdf.

$18 billion in 2017. According to Munich Re, 56 severe thunderstorm events occurred in 2018 resulting in 66 fatalities and approximately $18.8 billion in losses.[12]

The number of tornadoes fell to 1,124 in 2018 from 1,429 in 2017, according to the National Oceanic and Atmospheric Administration (NOAA). The 2017 total was the highest since 2011, when there were 1,691 tornadoes, including two spring events that resulted in more than $14 billion in losses. There were 10 direct fatalities from tornadoes in 2018, compared with 35 in 2017, according to NOAA.

Preliminary NOAA reports show there were 1,431 tornadoes in 2019 through November compared to 1,060 for the same period in 2018. Tornadoes killed 38 people from January to November 2019, compared with nine people for the same period in 2018. [13]

## Responding to the Risks

### *Research Support for Mitigation*

Fortunately, there are strategies to help the nation mitigate windstorm risks. The Congressionally established National Institute of Building Sciences (NIBS) examined various mitigation strategies to determine their cost effectiveness. In its *Natural Hazard Mitigation*

| National Benefit-Cost Ratio Per Peril | Exceed common code requirements | Meet common code requirements | Utilities and transportation | Federally funded |
|---|---|---|---|---|
| Overall Hazard Benefit-Cost Ratio | 4:1 | 11:1 | 4:1 | 6:1 |
| Riverine Flood | 5:1 | 6:1 | 8:1 | 7:1 |
| Hurricane Surge | 7:1 | Not applicable | Not applicable | Not applicable |
| Wind | 5:1 | 10:1 | 7:1 | 5:1 |
| Earthquake | 4:1 | 12:1 | 3:1 | 3:1 |
| Wildland-Urban Interface Fire | 4:1 | Not applicable | Not applicable | 3:1 |

*Figure 4: National benefit-cost ratios of hazard mitigation (NIBS 2019)*

[12] Insurance Information Institute. Facts + Statistics: Tornadoes and Thunderstorms. Accessed December 2, 2019. https://www.iii.org/fact-statistic/facts-statistics-tornadoes-and-thunderstorms.
[13] Ibid.

*Saves 2019 Interim Report*, NIBS found that adopting the 2018 editions of the International Building Code and International Residential Code provided $10 in mitigation benefits against hurricane winds per $1 invested.[14] Unfortunately, communities that have not updated to the 2018 codes have not captured the full benefit, leaving highly cost-effective mitigation practices on the table. Federal mitigation programs offered by FEMA, the Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD) generated $5 in mitigation savings against hurricane winds for every dollar invested. Unfortunately, due to the lack of adequate mapping of tornado risk, researchers were unable to conduct a similar analysis for tornado mitigation strategies (although tornado risk maps are being developed under the NWIRP program).

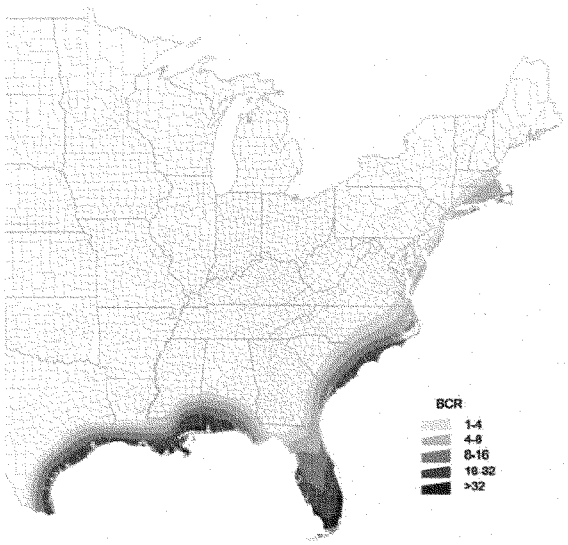


*Figure 5: Benefit cost ratio of hurricane wind mitigation through compliance with the 2018 IRC and IBC (by wind band) relative to 1990 requirements. (NIBS 2019)*

[14] http://www.nibs.org/mitigationsaves.

Other studies have examined the benefits of building codes in reducing the impacts of hazard events (many of them with strong wind components). A FEMA analysis from 2014 estimated approximately $500 million in annualized loss avoided in eight southeastern states due to the adoption of modern building codes.[15] In the eight years following Florida's adoption of a statewide building code, the code's adoption and application reduced windstorm actual losses by as much as 72 percent.[16] Effective and well-enforced building codes in Missouri reduced hail damage to homes by 10 to 20 percent on average.[17]

Investing in the application of existing mitigation tools like codes and standards is incredibly cost effective and reduces the burden on taxpayers and the federal treasury during disaster response and recovery while also minimizing casualties and property damage from these devastating events. NWIRP supported efforts to bring research to practice will produce new strategies for hazard mitigation that continue to bring down risk and add to the economic case for proactive efforts to reduce the impacts of windstorms.

***Variability in Code Adoption and Federal Support Efforts***

States and localities are responsible for the adoption of building codes and must adopt model codes for those codes to have effect. Communities amend model codes and utilize different code vintages. The corresponding heterogeneity in building requirements has consequences for our national resilience. According to FEMA, despite the benefits modern codes provide, more than two-thirds of communities facing damaging wind, hurricane, tornado, seismic, or flood hazards have not adopted disaster-resistant codes.[18] Modern building codes require storm shelters for schools in tornado prone regions. Yet of the 21 states that regularly face tornado risk, only about a third require tornado shelters for schools.

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[15] FEMA, Phase 3 National Methodology and Phase 2 Regional Study Losses Avoided as a Result of Adopting and Enforcing Hazard-Resistant Building Codes (2014).

[16] Simmons, K.M., et. al., Economic Effectiveness of Implementing a Statewide Building Code: The Case of Florida, Land Economics (2018).

[17] Czajkowski, J. & Simmons, K., *Convective Storm Vulnerability: Quantifying the Role of Effective and Well-Enforced Building Codes in Minimizing Missouri Hail Property Damage*, Land Economics (2014).

[18] Mitigation Framework Leadership Group, *National Mitigation Investment Strategy* (Aug. 2019). "Disaster-resistant codes" is defined as the two most recently published editions of the IRC and IBC.

Based on the variation in community resilience nationally, NIBS research, the recognition that continued federal post-disaster recovery funding is not sustainable and other factors, Congress and relevant federal agencies have undertaken efforts to shift the focus to pre-disaster investments. Many of these efforts rely on building codes as a strong component.

Recognizing modern model building codes' implications for disaster mitigation and the stewardship of federal post-disaster recovery expenditures, FEMA's strategic plan stresses: "[d]isaster resilience starts with building codes, because they enhance public safety and property protection." In the Plan's very first objective, FEMA highlighted the importance of the Agency's "advocate[ing] for the adoption and enforcement of modern building and property codes."[19] FEMA has deemed adherence to current model codes to be so important that it will not fund rebuilding of public facilities post-disaster if that construction would otherwise be built to outdated standards.[20] State and local adoption of up to date building codes is a budgetary performance metric for the Agency.

Congress shares FEMA's position. Twice last year Congress passed, and the President signed into law, measures that incentivize the adoption and application of modern model building codes through enhanced federal cost shares for post disaster rebuilding, new grants for states and localities both pre- and post-disaster and by making pre-disaster mitigation grant applicants more competitive based on their adoption of up to date model codes.[21]

Requiring adherence to current building codes through federal programs tracks the just released National Mitigation Investment Strategy (NMIS). The NMIS, released by the FEMA-chaired Mitigation Framework Leadership Group (MitFLG), presents a unified national strategy on mitigation investment that reduces risks posed by natural hazards and increases the nation's resilience to disasters. The MitFLG is composed of 14 federal agencies and departments as well as state, tribal and local officials and is charged with coordinating the strategy's implementation. One of the most critical recommendations in the strategy is "[u]p-to-date

[19] FEMA's 2018-2022 Strategic Plan (2018).
[20] Public Assistance Program and Policy Guide, FP 104-009-2 (2018).
[21] Disaster Recovery Reform Act of 2018 (within the Federal Aviation Administration Reauthorization Act of 2018, P.L. 115-254) and the Bipartisan Budget Act of 2018 (P.L. 115-123)

building codes and standard criteria should be required in federal and state grants and programs."[22]

The impact of investments made under NWIRP in advancing criteria in codes and standards can be amplified through the federal investments already being made in encouraging code adoption and enforcement. Without a concerted effort to advance wind provisions, such a multiplying effect is lost.

## Notable Successes under NWIRP

With the limited funding available to date, NWIRP has fostered several notable successes in advancing wind hazard mitigation.

NWIRP's collaborative focus encouraged the creation of FEMA publications P-320 and P-361, which captured the latest science on the design and construction of storm shelters to protect building occupants in a tornado or hurricane, and which served as precursors to the subsequent *ICC/NSSA Standard 500: Standard for the Design and Construction of Storm Shelters*. This standard was voluntary within the 2009 IBC, but with the support of the NWIRP agencies and risk data they brought to bear, beginning in 2015 the IBC has required that new K-12 schools and emergency responder facilities in the most tornado prone areas include storm shelters compliant with ICC/NSSA Standard 500. FEMA's hazard mitigation grant programs recommend funding storm shelter construction, which also generates some of the greatest benefit-cost analyses (BCAs) under the Agency's BCA tool. The greatest success achieved by this joint effort: there have been no fatalities in properly designed and constructed safe rooms.

A second notable success is the current effort by NIST and NOAA to develop a standard on how to measure tornado wind speeds. As an extension of these efforts, NIST is developing tornado risk maps and associated building design procedures that will ultimately be incorporated into codes and standards to better scope building resilience requirements to risk profiles. These design procedures will be the first tornado design procedures developed worldwide. This

[22] https://www.fema.gov/national-mitigation-investment-strategy.

project was initiated following the Joplin, Missouri tornado of 2011. These maps have the potential to unlock opportunities for additional research into specific design measures and benefit cost analysis. This includes an examination by NIBS to determine the cost effectiveness of mitigation measures against tornado risk.

Additional updates to codes and standards made by the NWIRP agencies have been successful, including the development of new design wind speed maps that have been incorporated into the 2018 IRC and IBC that dictate minimum structural design to mitigate against wind risk by geography. Following Hurricane Maria, as Puerto Rico worked to update to the 2018 I-Codes, FEMA, NOAA and NIST collaborated under NWIRP to incorporate updated local wind maps for Puerto Rico's new code.

## NWIRP Funding and Reauthorization

Despite the significant impacts of windstorms and the potential to reduce damage to property, loss of life and injuries through NWIRP, appropriated funding for the program has been limited. Such an approach has multiple drawbacks:

- Potential windstorm-related projects must compete with other programs (some deemed to have higher priority) for limited money;
- Projects that do get funded are prioritized based on their ability to meet other agency objectives, thus limiting the strategic nature of efforts intended by NWIRP;
- NWIRP is unable to establish a "brand" which centers wind hazard-related research and expertise and helps build a workforce with wind-hazard expertise (see further discussion below); and
- Program agency staff have limited opportunities to build rapport and establish the true collaboration intended by Congress.

The authorization levels provided in the 2015 reauthorization bill ($21,400,000 annually: $5,332,000 for FEMA, $9,682,000 for the National Science Foundation (NSF), $4,120,000 for NIST and $2,266,00 for NOAA) represent a reasonable level of funding for an early-stage, multi-

agency, multi-faceted program. Despite the progress to date, ramping up to the program's full potential will require regular appropriations over the next few years. An active authorization, along with champions, both in Congress and the Administration, are critical toward ensuring regular investments.

In contrast to NWIRP, Congress appropriated $164.5 million for program activities of the NEHRP in FY2019.[23] The 2018 NEHRP reauthorization act authorizes appropriations for NEHRP activities from FY2019 to FY2023, for a total amount of about $760 million over the five-year span, or approximately $152 million annually.

## Opportunities and NWIRP Recommendations

While NWIRP can point to successes, there are opportunities to further enhance the reach of the Program and address the current and pending impacts presented by windstorms. These opportunities largely fit under the existing Program priorities as outlined in the 2015 reauthorization, but as a future reauthorization is considered, the Code Council believes the following efforts should be highlighted.

- **NWIRP should be reauthorized for a period of at least five years to maximize the impact on research and application of research into codes and standards.** Like NEHRP, a five-year reauthorization for NWIRP is preferable. The model code development process operates on a three-year cycle. A five-year timeframe for NWIRP would allow time for development of code change proposals and educating participants in the code development process on the intent of the changes. Once the model code is updated, state and local governments generally start their update process—a time when technical assistance on NWIRP recommended specific changes and general support for updating the code is needed. Research cycles are also more consistent with a five-year authorization window. Complex engineering and social science research, as well as workforce development, are ideally carried out in three-year increments. Once findings

[23] NEHRP. 2005-2019 NEHRP Agency Budgets. https://www.nehrp.gov/pdf/2005-2019%20NEHRP%20Agency%20Budgets%20from%20SDiaz%20for%20website_2019.pdf

are fully developed, translating the results to action in the form of criteria or other guidance takes addition time. Authorization levels should be maintained, consistent with those in the prior reauthorization. Dedicated funding at these levels must be appropriated to allow effective execution of the program, build the program's brand and support achievement of its objectives.

- **The U.S. Department of Housing and Urban Development (HUD) should be designated as an NWIRP program agency with responsibility for reducing the impacts of windstorms on manufactured housing.** HUD should also be formally included on the Interagency Coordinating Committee on Wind Impact Reduction.

  Manufactured housing is built on a permanent chassis and subject to requirements of the Manufactured Home Construction and Safety Standards developed by the Department of Housing and Urban Development (HUD) rather than the state or local building code.[24] Manufactured homes are often seen as an affordable option for low- and middle-income households. Unfortunately, a disproportionate amount of fatalities from windstorms occur in manufactured homes.[25,26] HUD's participation would help ensure windstorm research findings are translated to design, construction and installation requirements for inclusion under the HUD Manufactured Home Construction and Safety Standards.

- **NWIRP agencies should work with codes and standards developers to advance standards and guidance for the evaluation and retrofit of existing buildings.**

  The natural turnover in the nation's building stock is estimated at one to two percent annually. The greatest immediate exposure to windstorm impacts is in today's existing

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[24] This is in contrast to modular, pre-fabricated or panelized homes which must comply with the building code in place at the final building site.

[25] Ashley, W. S., 2007: Spatial and temporal analysis of tornado fatalities in the United States: 1880-2005.American Meteorological Society - Journals Online: Weather and Forecasting, 22, 1214-1228.

[26] Sutter, D., and K. M. Simmons, 2010: Tornado fatalities and mobile homes in the United States. Natural Hazards, 53, 125-137.

buildings. However, guidance on the retrofit of existing structures to withstand windstorm events can be improved. Building owners, designers and contractors need tools to evaluate vulnerabilities and identify cost-effective strategies to reduce those vulnerabilities.

Research is needed to build upon and expand retrofit standards for windstorm risk. The International Existing Building Code (IEBC) currently includes retrofit guidelines for gable ends and roof deck fastening, but this guidance could be more comprehensive.

- **NWIRP agencies should undertake research into future intensity, duration and frequency of windstorm events and advance the incorporation of findings into guidance for designers, owners and operators of buildings and infrastructure.**

The design, construction and operation of today's built environment is largely based on the science and experiences of the past. Yet, the future requirements for buildings and other infrastructure are likely to be vastly different. Natural hazard events are changing in frequency, intensity and impact. This new paradigm requires that the planning, design, construction and operations workforce has the tools to address these new types of challenges.

Several codes and standards developers are working to ensure codes provide requisite protection of buildings and their occupants during the buildings' lifetimes. The Code Council recently announced an initiative with code development organizations from Canada, Australia and New Zealand to collaborate and share knowledge, research and best practices to further prepare the building industry for increasingly severe weather events.[27] The American Society of Civil Engineers (ASCE) has also begun to examine how its standards and the design process itself must evolve.

NWIRP can play an important role in addressing climate resilience by bringing representatives from the climate science and building science community together. This

[27] https://www.iccsafe.org/about/periodicals-and-newsroom/the-international-code-council-launches-global-initiative-on-building-resilience/

effort would build understanding of the types of information the building industry needs to effectively address these changing risks and the climatic information that climate scientists can provide.[28] NWIRP is in a unique position to assist in the development of solutions given its agencies represent both research and applied sectors. Additional agencies with expertise and experience in this area that should be integrated into such an effort include NASA, the Federal Highway Administration, General Services Administration, U.S. Army Corps of Engineers, Department of Defense and the U.S. Global Change Research Program.

- **Support increased economics research to inform codes and standards development and the adoption of such criteria and social science research to support decision making.**

  Achieving resilience requires the engagement and expertise of multiple disciplines including economics and social sciences. Engineering-based solutions should not be developed in a vacuum. Effective deployment requires understanding the economic factors that influence decision making and the messages and communication that will drive action. More robust benefit cost analysis will support better decision making both in research and the deployment of specific mitigation measures.

  Public education on risk and vulnerabilities associated with windstorms and other hazards will help create awareness and drive demand for wind-resistant features including adoption of up-to-date building codes and retrofits of existing buildings. Social scientists must be engaged to help formulate the educational messages and identify the most effective outlets for dissemination.

  Social science initiatives are also needed to better understand what motivates state and local policymakers to update building codes. What data is needed, what messages resonate, and who is an effective messenger? A robust economic analysis is important

[28] National Institute of Building Sciences. Moving Forward: Findings and Recommendations from the Consultative Council. 2014.

to show the benefits of windstorm impact mitigation strategies and the potential risk of inaction.

- **Create a formal linkage between NWIRP and other federal hazards programs to promote efficiency and increase efficacy.**

  Across the country, citizens are exposed to a variety of hazards, not just windstorms. Communities rarely make decisions in isolation. Federal agencies (including the NWIRP agencies) support programs that address the impacts from other specific hazards and support multi-hazard approaches to increasing resilience.

  Creating formal linkages between the NWIRP and these existing initiatives can help optimize limited funding and amplify the impact of NWIRP activities. In many cases solutions identified to mitigate one type of hazard may inform potential solutions for another hazard. NEHRP has extensive experience in translating research to practice. Lessons learned could be applied to the NWIRP initiatives. Fire programs in the USDA Forest Service and the U.S. Fire Administration and NIST resilience programs could provide additional insight.

  FEMA and the Department of Homeland Security (DHS) have multiple initiatives that look at addressing hazard risk holistically. Assuring consistency in how wind-related risks are handled across agencies and tools is essential. Specific opportunities for increased collaboration include FEMA's HAZUS tool that supports scenario planning, the FEMA Benefit Cost Analysis tool which supports grantmaking and decision making, and the DHS Cybersecurity and Infrastructure Security Agency (CISA) which focuses on threats to critical infrastructure.

  Coordination with mitigation and recovery grant programs from FEMA, HUD, the Small Business Administration, EDA and others would allow grant administrators to prioritize strategies that have the greatest return. Finally, cross programmatic coordination would help support sharing of lessons learned; coordination of codes and standards development, adoption, enforcement and technical assistance messages and strategies;

and potential development of strategies that provide multiple hazard mitigation benefits.

- **Build NWIRP's brand to support achievement of its objectives**

Unlike NEHRP, NWIRP has no consistent branding. There is no logo that allows easy identification of resources or guidance produced under the Program. The NWIRP web presence is minimal, limited to a few pages hosted by NIST that provide general program management documents—it does not include a compendium of NWIRP technical documents or information on current activities.

This lack of branding results in multiple challenges for the program:

- The program's successes go unheralded, undermining efforts to promote future resource investment.
- To practitioners and state and local policy makers who are unaware of the program, the resources developed by the program agencies appear disjointed or unrelated. There is no clear, "authoritative source" of windstorm mitigation activity within the federal government. This perception undermines the influence of the guidance produced.
- For potential new entrants into the wind research or resilience workforce, the lack of consistent messaging imparts a perception that the federal government lacks interest in tackling windstorm-related challenges and that there is limited potential in the field.
- As proposals are made to codes and standards development bodies, the weight of NWIRP as the multi-agency federal initiative to mitigate wind risk may be more effective than individual agency actions (this is particularly true if industry is engaged under the NWIRP banner).
- Enhanced recognition within program agencies could lead to greater engagement of staff in NWIRP activities and increase opportunities for collaboration and coordination.

- **Strengthen the connection between NWIRP activities and private sector codes and standards developers that will ultimately incorporate NWIRP findings and solutions into guidance for the design, construction, operations and regulatory community.** The prior National Advisory Council on Windstorm Impact Reduction included "industry standards development organizations" as a member category but limited the Committee's role to recommendations for the program itself. A formal liaison role to implementers like the International Code Council, American Society of Civil Engineers (ASCE) and the Insurance Institute for Business and Home Safety (IBHS) would be valuable and could streamline action.

## Conclusion

Thank you for the opportunity to provide testimony in support of reauthorization of the National Windstorm Impact Reduction Program (NWIRP). Despite limited funding, the program has achieved considerable success in reducing the impacts of windstorms on human life and property. Reauthorization coupled with dedicated funding will provide the NWIRP agencies with the resources needed to support the development and deployment of hazard mitigation measures commensurate with the risk communities face.

The International Code Council and the Alliance for National & Community Resilience will continue to provide communities with the code, standards and benchmarks they need to be safe and resilient. We stand ready to support the NWIRP agencies in achieving their goals of understanding windstorms and assessing and reducing their impacts.

ICC INTERNATIONAL CODE COUNCIL®

Alliance for National & Community Resilience

BIO FOR RYAN M. COLKER, J.D., CAE

Ryan M. Colker is Vice President, Innovation at the International Code Council. He also serves as Executive Director of the Alliance for National & Community Resilience (ANCR), a national coalition working to provide communities with the tools necessary to holistically assess and improve their resilience. Prior to joining ICC, Colker served as Vice President at the National Institute of Building Sciences where he led efforts to improve the built environment through the collaboration of public and private sector industry stakeholders. At NIBS he directed the Consultative Council which develops findings and recommendations on behalf of the entire building community and served as staff director of the Council on Finance, Insurance and Real Estate; the National Council on Building Codes and Standards; the Off-Site Construction Council and the Institute's STEM Education Program. He speaks and writes frequently on emerging issues within the built environment including resilience, building performance, and off-site construction. Colker is the editor of the book *Optimizing Community Infrastructure: Resilience in the Face of Shocks and Stresses.* Previously, he served as Manager of Government Affairs for ASHRAE and Program Director of the Renewable Natural Resources Foundation. He graduated from The George Washington University Law School, and holds a B.A. with honors, in environmental policy from the University of Florida.

Chairwoman STEVENS. Thank you. At this time we'll begin our round of questions, and the Chair will recognize herself for 5 minutes of questioning.

It's in our documentation here that the last approved budget for NWIRP was around $5.7 million for Fiscal Year 2019. Dr. Weaver, can you talk a little bit more about the three pillars of NWIRP, in particular the ways in which you're working with communities beyond just implementing the studies, if at all, particularly around promoting understanding, and some of the adaptation and what goes into that, particularly with those limited resources that you have available?

Dr. WEAVER. Sure. Well, the NWIRP program, at its core, is an inter-agency coordination program, so obviously——

Chairwoman STEVENS. And I was talking about NIST.

Dr. WEAVER. Yes. So obviously we look to leverage, but we develop the science that goes into standards and codes. So one of the anchors of that would be our post-windstorm investigation. So if you look at either the Joplin tornado recommendations, or that which will come out of our Hurricane Maria investigation, we lean on that scientific research to promulgate that out into the world so that decisionmakers can then take that and balance their priorities in the way that they see fit.

Chairwoman STEVENS. And is it only buildings that you guys are looking at? Are you looking at other elements of infrastructure, particularly as windstorms become harsher, and we've even seen, in Michigan, new names for these types of storms. Bomb cyclone is one that came up. Even the derechos are newer to the lexicon. I know the Washington, D.C. area was hit with one within the last 10 years. But in particular, you know, you think about being a passenger, or a driver in a vehicle, or someone sitting in a plane that's about to take off, and I don't know if your research abilities or your standards recommendations are able to extend that far?

Dr. WEAVER. So we do focus—in fact, one of the strengths of NWIRP is that, when we conduct our post-windstorm investigations, NWIRP's authority is much broader than some other authorities that we use at NIST, and so it allows us to look at things that are not just directly related to the building, but may also feed into the building. So distributed infrastructure, waste water systems, electricity. That's one of the hallmarks of our Hurricane Maria investigation, we're looking at an island-wide disaster, and not just what happened in a given building. That's, of course, important, we're looking at that as well, but how the services were disrupted, how the landslides may have blocked transportation infrastructure, leading to people not being able to get to hospitals. So we are looking at things like that, and it's a highly interdisciplinary investigation because of that situation.

Chairwoman STEVENS. And the warnings become all the more critical and imperative for us, particularly as things might happen quickly, and, you know, heaven forbid you find yourself in one of those circumstances. I will actually never forget driving in a derecho, and getting to a restaurant where, you know, we had branches coming at us, you know, many trees fell, and we walked into the restaurant, no one had any idea what was happening, but, you know, we saw it occur before our eyes.

And, Mr. Colker, you know, some of this is what you were just discussing in your testimony, around kind of the need for the awareness about the NWIRP program, and what these standards lead to, particularly as compared to something like the National Earthquake Hazards Reduction Program that, you know, has a little bit more staying power, and is a little bit more stable, but could you just talk a little bit more about how we can make NWIRP more stable throughout the community? And obviously we're so enthusiastic that it's inter-agency, but any other ideas that you have on that front?

Mr. COLKER. Yes. I think, certainly, having a long-term authorization. NEHRP is authorized for 5 years, which allows that collaboration, the engagement in the codes and standards development process, building sort of that research agenda over a longer period of time. Certainly funding is key to allowing that collaboration to happen. I think also developing a specific brand for the NWIRP program which would drive, you know, researchers and notoriety for the things that the program is doing, and can be doing into the future.

Chairwoman STEVENS. Great. Well, I'm going to yield back the remainder of my time, but thank you all so much for your expert testimony and what I think is going to contribute to some good work to come for all of us. So the Chair is now going to recognize my colleague Dr. Baird for 5 minutes of questioning.

Mr. BAIRD. Thank you, Madam Chair. And, Dr. Weaver, I'm going to start with you on the NWIRP, which was created, what, in 2004, and under the Office of Science and Technology Policy? And then it was re-authorized again in 2015, and they put NIST as the lead agency. So I guess my question to you is has this made a difference, for NIST to be the lead agency? Has that worked out well, and has that been successful?

Dr. WEAVER. Well, I think it has. I mean, obviously there's always more that we could be doing, but I think one of the original issues was that there was rotating leadership in the first incarnation of the legislation, and I think having a home base like NIST has brought some stability to the program. I'll also say that NIST is a non-regulatory agency, so we're a user of a lot of the different products that come out of the other agencies, and I think it strengthens the program by having more of a user base, more of the applied science base from NIST to lead the program.

Mr. BAIRD. Thank you. Then, for all of you panelists, because we have such fantastic expertise here, Purdue University has an award from the National Science Foundation to run the Network Coordination Office for the Natural Hazards Engineering Research Infrastructure Program, and that network enables researchers to explore and test groundbreaking concepts that protect homes, businesses, and infrastructure lifelines from the impacts of earthquake, wind, and water hazards, and enabling innovations to help prevent natural hazards from becoming societal disasters. So can each of you discuss the importance of having an integrated approach to natural disaster research, and how hazard-specific programs can better work together? So I'll start with you, Doctor——

Dr. WEAVER. Sure. So, as I mentioned throughout my testimony, as is shown in our strategic plan, disasters are not just about the

hazards themselves. That's certainly an important component. You have a hurricane, without a hurricane, you don't have a disaster, or without a tornado, you don't have a disaster.

But really getting to where the rubber meets the road, in terms of conducting experiments on engineering, and how that relates to the meteorological factors, I think NHERI is a really important player in connecting those two fields. And then also bringing in the social science aspect and the other interdisciplinary nature, it's really special in that regard.

General TAFANELLI. I think two things. Anytime that we can have an integrated approach to any of these type of events, we're going to be better off for that type of integration and close coordination working with other agencies. One of the things, as we pull these things together, even if they're not specific to a certain type of disaster threat that faces a particular part of the Nation, it doesn't mean there aren't lessons to be learned, and there's parts and pieces that can be adapted for local utilization. And we do that with the Hazus program, while it doesn't necessarily give us data specifically for tornadoes, we can use that in other areas. But I think anytime that we can collaborate and integrate those research efforts, it benefits all of us on the ground.

Dr. ZUO. I think NEHRI is an entity that really opened a lot of doors for a lot of researchers, and we benefited a lot from that. For example, a lot of people want to do wind-related research, but they just don't have the large facilities like the wind tunnels at Florida and the University of Florida to work on what they want to work on. Now NSF opened this NEHRI Program, that gives everybody access to that. And, also, NEHRI has a cyber infrastructure facility at the University of Houston. You can comb through all the measures you develop, and all the data resulting from all the research. So that gives the community a lot of resource that you can work on. So I think this approach is very critical for the, you know, joint effort and success of a program like NWIRP.

And also, as I said just now, the tornado research community right now doesn't have a facility to work on their problems, so if we can also include a tornado research facility in the NEHRI Program, that'll really further help the natural hazard research community. Thank you.

Mr. COLKER. Codes are built to address all the hazards a community faces, and so really understanding all of the opportunities to address multiple risks through various different opportunities, and capture multiple benefits, is certainly of value to the code, and the cost-effectiveness of bringing these measures to the public.

Mr. BAIRD. Thank you, thank all of you, and I yield back my time.

Chairwoman STEVENS. Yes. Chair recognizes Chair Fletcher for 5 minutes of questioning.

Chairwoman FLETCHER. Thank you very much. Thank you all for your testimony, for being here today. I want to cover two topics with my 5 minutes, and I'm going to put some questions out to all of you to answer, or weigh in on as you choose. But first I want to talk about the funding and reauthorization of NWIRP. Dr. Weaver, you talked in your statement about the cost of inaction, and, Mr. Colker, you also talked about the appropriations cycle, and the

challenges faced with a 5 year appropriations cycle for NWIRP, and so I guess one of my questions is, as we think about how to have this program realize its full potential, what about the way that we're currently approaching it—what opportunities are we missing by allowing the program to lapse, in terms of congressional authorization? What are the things we're missing? Anyone who wants to weigh in on it. Mr. Colker, if you want to go first?

Mr. COLKER. I can certainly start. I think one of the important things to recognize is the code cycle runs on a 3-year update process, and so it takes some planning to be able to translate the research that's coming out of academia and other partners into code change proposals, sort of institutionalizing those proposals to the folks that participate in the code development process, getting those code change proposals adopted, and then ultimately engaging State and local governments in updating their code. So, you know, that is certainly a multi-year process, and if there's not funding or authorization in place, you miss gaps within that process, and that continuity can't continue.

Chairwoman FLETCHER. Thank you, that's helpful. Does anyone want to weigh in on missed opportunities or gaps that you see because of the funding challenges and the authorization cycle? OK. I will move on to my other topic, which will definitely take some time for everyone, which is something we talk about a lot on this Committee, as we're tackling various challenges that we face, is talking about incorporating issues relating to climate change into NWIRP.

So I think in your testimony, again, Mr. Colker, you suggested that building codes need to better reflect future forecasts of storm intensity, something we know a lot about in my district, that there's an increasing intensity, frequency, and impact of some of these storms that we're seeing. So most of the built environment now is based on what we know from the past, and continuing in this model may not be sufficient to protect what we have built and what we're doing going into the future as we see the effects of climate change. How can we better integrate what we know now about climate change, and our views of the increasing threats of severe weather in various forms into engineering our future buildings for resilience?

Mr. COLKER. I can certainly start. The Code Council, and several other standards developers, including the American Society of Civil Engineers, have started sort of down that road of exploring, you know, what do codes and standards look like to address future risk. We've also started conversations with our code development colleagues in Canada, Australia, and New Zealand to start to address these risks.

I think the important opportunity within the NWIRP agencies is actually bringing some of the climate science expertise that's within NOAA, and some of the research organizations, with the building science community that's represented by NIST, and FEMA, and other organizations to figure out sort of what is that basis for future codes that recognize those changing risks.

Chairwoman FLETCHER. All right. Does anyone else want to weigh in? Dr. Zuo?

Dr. ZUO. Yes, I want to add that probably it will take the atmospheric science community and the—community to work—to look at problems like these. These are large-scale problems. I don't think either one of these can solve the problem. Thank you.

Chairwoman FLETCHER. Thank you. Dr. Weaver?

Dr. WEAVER. Yes, just one comment. I mean, the U.S. Global Change Research Program mentions this in their quadrennial report, but much of the research, as my two other colleagues mentioned, you have two different camps, and so trying to integrate the atmospheric science and the engineering world would go a long way toward being able to look at that problem. One kind of stops where the other one doesn't pick up, and they're not connected as well as they could be.

Chairwoman FLETCHER. Thank you. That's helpful. Well, with that, Madam Chair, I will yield back the balance of my time. Thank you all very much.

Chairwoman STEVENS. And now the Chair recognizes Ranking Member Marshall——

Mr. MARSHALL. All right.

Chairwoman STEVENS [continuing]. For questions. Yes.

Mr. MARSHALL. Thank you, Chairwoman. I'll start with Major General Tafanelli. I want to talk a little bit about the mitigation efforts in Kansas, what we've done. Here, on this Committee, we oversee work with NOAA and the National Weather Service. What type of collaboration projects have you done with them, with the State Emergency Operations Center, if any? What's working? What do you want to brag about? We're doing something right there, it sounds like.

General TAFANELLI. Congressman Marshall, I will tell you that the biggest thing that we see from the partnerships that we didn't see previously is now anytime we have activated the State Emergency Operations Center, we have representatives from the National Weather Service in there, and the tools that they're able to provide, the insights that they're able to provide decisionmakers as we look to position resources, make informed decisions about storm track, severity, and those things, is really invaluable.

When we look at, particularly from a NOAA perspective, the ability that they can bring from a data perspective, really kind of helps us more on the planning side of what we do, because they have all of the historical records in that data that can then help us as we work with our mitigation plans, and when work with other planning efforts across the State.

Mr. MARSHALL. Is there anything we can do to push or nudge them along to be more helpful to you all? Any suggestions?

General TAFANELLI. You know, I would say—I think one of the things that we really see is that is getting the people with the right information in the room, and sometimes, as we go higher up in the food chain, if you will, at the Federal level, or with some of the other entities that are out there, just knowing what capabilities that they're able to bring to the table really allows us a better opportunity to make informed decisions, and really do the kinds of things that we need to do to protect the public, and have the necessary response mechanisms in place.

Mr. MARSHALL. OK. Let's talk about the building codes that you mentioned a little bit, General Tafanelli, as well. You know, as I think about growing up in Kansas, it would be unusual to not have a thunderstorm with an 80-mile an hour wind at least once a year hit your community. And, again, growing up we'd be listening to the radio, and I'd hear a tornado hitting the southwest side of Wichita, and my dad saying, "my gosh, that's horrible. Well, Dad, how come? Well, that's where all the trailer homes are."

You know, are we getting any better? Are we safer today, or is that still a big concern? What are rural communities doing, along with urban communities, to address some of those issues, and any thoughts on how we can improve that situation?

General TAFANELLI. I would say that there's more of an awareness now within our communities and our citizenry out there, and some of the things that we have seen—with the example of mobile home parks, while it may not be practical for individuals to have storm shelters at each individual trailer site——

Mr. MARSHALL. Right.

General TAFANELLI [continuing]. Many of those now do have, within mobile home parks, storm shelters that are in place for that community to be able to get to. When you couple that with the ability of systems today to be more predictable, in terms of forecasting where storms are going to be at particular times, it gives more people an advantage to take the necessary precautions to get to a site where they do have some secure cover over them in the event of that storm.

Some of the things that we've done internally, from a rural perspective, has been really our safe room program, and we've put in a number of safe rooms at schools, in large part because approximately 20 to 25 percent of the community is in a school setting at some point in the day, whether that's in the classrooms, or whether that's at school events where the community may be involved, and that's especially important in the rural parts of Kansas. So one of those things is, again, taking that approach is why we really have invested in the safe room program.

One of the other programs that we've done on a community basis is in Dodge City, Kansas, and we were able to do a monolithic dome structure that is capable of housing almost 4,000 individuals. Now, they use it for other purposes, but there again, that's more of a community-based approach to providing those kind of safe structures.

Mr. MARSHALL. OK. Thank you so much, and I yield back.

Chairwoman STEVENS. Thank you. And, at this time, the Chair recognizes Congresswoman Bonamici for 5 minutes of questioning.

Ms. BONAMICI. Thank you to the Chairs and Ranking Members, but thank you especially to the witnesses for being here, and for your expertise. You know, across the country we are seeing more frequent and intense extreme weather and climate-related events. Last week we had what was referred to as a bomb cyclone in the Pacific Northwest. It hit the Pacific Coast. According to the National Weather Service, the storm generated sustained winds of 85 miles an hour, with gusts up to 106 miles per hour on the southern Oregon coast. It shut down a major highway in both directions. Travelers were stranded in their cars. Twenty-thousand people

were without power. That was just last week. And we know today's infrastructure and building standards do not take future climate trends into account, so I'm glad we're having this conversation today. We know that current levels of infrastructure investment in this country are not enough to respond to these threats.

According to the Fourth National Climate Assessment, read from the text, "extreme weather events are expected to increasingly disrupt our Nation's energy and transportation systems, threatening more frequent and longer lasting power outages, fuel shortages, and service disruptions." So we know we need to do more to help our communities access information and data. They need to prepare for extreme weather events, including windstorms. And we know from the testimony that these investments make sense. They save lives and property.

Dr. Weaver, you mentioned in your testimony that one of the goals of NWIRP is to improve the understanding of windstorms on communities, and I have two questions about that. First, how does NWIRP engage with local and regional stakeholders to determine where to direct future scientific research efforts, and then second, how do the four program agencies under NWIRP break down their research to a usable application level for localities?

Dr. WEAVER. Sure. Thank you for the question, Congresswoman. So, when we were developing the NWIRP strategic plan, this was a very large effort—we conducted outreach and solicited public comment, so we received comments from a range of different organizations, so that's one way that we tried to get the advice from stakeholders at the local or State levels. Our engineers also sit on committees of the American Society for Civil Engineers, which is a standards development organization that develops the standards that protect communities across the country.

In the original reauthorization for this legislation, the National Advisory Committee for Windstorm Impact Reduction had broad representation from across different communities, and so that's several ways that we bring in local and State stakeholders into helping us decide what the research priority should be.

Ms. BONAMICI. How do you make it usable for local governments and localities?

Dr. WEAVER. So much of what we do is at the national level, and so trying to provide the best available science to inform engineering standards, and then that can be useful to local decisionmakers, where they have to balance different priorities.

Ms. BONAMICI. Thank you. I'm going to move on to another question. Dr. Zuo and Mr. Colker, in your testimony, you each reference the disproportionate effects of windstorms on low-income communities, and especially residents in manufactured homes, and I know the Major General also mentioned that. Everyone should have a roof over their head, and with the challenges of affordable housing, manufactured homes often provide millions of Americans with a vital source of housing, but those are oftentimes families with low incomes, or in rural areas. There are more than 12,000 manufactured homes in the district I'm honored to represent in northwest Oregon, and I've heard from many residents of those communities about the challenges they already face.

So, Dr. Zuo and Mr. Colker, would the Department of Housing and Urban Development's participation in NWIRP strengthen the Federal response to this, or socioeconomic consequences of windstorms, and what role could HUD play as a program agency under NWIRP? Mr. Colker, I know you mentioned it specifically in your testimony.

Mr. COLKER. Sure, absolutely. I think one of the challenges with manufactured housing is that it's not developed through the international code——

Ms. BONAMICI. Right.

Mr. COLKER [continuing]. Process, but rather the requirements are developed through a HUD committee, which ultimately, you know, HUD decides what's incorporated into those standards. And so, certainly, having a directed engagement of HUD in the NWIRP program, and specifically how to cost-effectively apply the research outcomes from NWIRP into the HUD code would be incredibly——

Ms. BONAMICI. Yes. I'm also out of time. Dr. Zuo, do you agree with that, it'd be helpful to have that input?

Dr. ZUO. I agree with that, and I will also say there probably should be dedicated resources for that program.

Ms. BONAMICI. Thank you very much. And I know a lot of the manufactured homes are older as well, which creates additional challenges. And I yield back any time. Thank you, Madam Chair.

Chairwoman STEVENS. Now recognize Ranking Member Lucas for 5 minutes of questioning.

Mr. LUCAS. Thank you, Madam Chair. General, I couldn't help but note you mentioned Kansas examining the implementation of a residential safe room program very similar to what we're doing in Oklahoma. And with, in an average year, 80 deaths, 1,500 injuries, it would seem that that's a critically important one, and I bring that up for a couple reasons. One, my understanding is there's not been a single reported failure of a safe room, if it was constructed to FEMA's criteria. That's pretty impressive. I also note that back in 1999, along with Congressman J.C. Watts, I represented part of South Oklahoma City. He represented Moore, I represented part of Del City also. But we had an F5 roll through, some estimates 300 mile an hour winds, and the path was such—I've seen tornadoes in Oklahoma that were destructive, but this one literally not only picked the asphalt up from the streets, it pulled all the grass out of the ground. But when we flew the path afterwards, and President Clinton came down at the time, the amazing thing to me was this string of little concrete boxes in the path that survived.

Touch for a moment, if you would, on the importance of collaborating with other States in these kind of programs, and, if you would, my final point—and, of course, I'm very proud of NOAA, and the National Weather Service's facilities at the Storm Prediction Center in Norman, Oklahoma, discuss with us for a moment, whether you have a safe room or not, the difference that the last 2 decades have made, where we've gone from an average of 7 minutes warning to 14 minutes warning. If you'd touch on that too?

General TAFANELLI. Ranking Member Lucas, thank you for the question. I too have seen far too many tornadoes, and I am always amazed at what Mother Nature can do, with regards to what it will

take out, and what it will leave, and just the overall destructive damage. From a collaboration perspective, what we have found, working with Oklahoma, Ohio, and a number of other States, is that, looking at their programs, it doesn't mean that we'll actually implement it the same way, because while each State, each region, has its own certain dynamics that it must kind of work through, but what we found is there's always a willingness to share that information between the State Hazard Mitigation Officers, and even at my level, about how we can prepare for, respond to, and recover from disasters in a better manner.

With respect to what we do with the National Weather Service, and—really comes out of the Storm Prediction Center, going back a number of years being involved in this field, what I am amazed with is the precise nature at which we can provide advance warning that didn't exist 10 years ago, 20 years, 30 years ago. And I can't tell you or quantify the lives saved because of that advance warning, and it really is—we stress a lot at the local level about everybody has a role to play, so individual citizens need to be prepared. They need to have a plan in the event of emergency. We talked to them about tuning in to their local weather channel during times of significant weather to be apprised. They can log in their own street address so that they're notified of when a particular storm track may hit their area so that they can take the necessary precautions. Those things didn't exist before, and so I think that, as technology continues to get better, that notification, and the benefit that that has, will continue to increase.

But I've also noticed, on the other side, that there's some hesitance in individuals because they'll look at that map and say, well, it's not exactly over my house, it's a half a mile away. Or, living in Oklahoma or Kansas, the number of individuals that will go out and stand on their porch, or on a deck, and look to see where the tornado's at. You know, I'm constantly reminded about those things, that sometimes if you've seen one tornado, you probably don't want to stand and see the second done.

Mr. LUCAS. The often used description at home is when you hear the freight train coming down the tracks, it's on you, but when you hear the freight train, it's too late. That 14 minutes means the difference between getting your children, your dog, your spouse, your neighbors into that concrete box with you, but, again, based on history, if you build your safe room to standards, you're going to survive, right, General? If you're in that safe room.

General TAFANELLI. That is exactly correct. I don't know the statistic of anybody that's been pulled out of a safe room dead.

Mr. LUCAS. Point made. Thank you, General. Yield back.

Chairwoman STEVENS. The Chair now recognizes Mr. Beyer for 5 minutes of questioning.

Mr. BEYER. Madam Chair, thank you very much, and thank you all for being with us. To follow up on the Ranking Member's 14-minute comment, Dr. Weaver, you wrote and talked about how—that right now we're depending—that we want NIST to encourage a spatially resolved real-time basis to supplement the currently deployed official binary warn/no warn system, and moving from a teletype deterministic watch warning to a high-resolution probabilistic hazard information spanning period from days, to within

minutes. There seem to be, you know, really sort of major shifts from what will it take us, in terms of the warning time. If we're 14 minutes now on average, does moving from binary system to something that's spatially resolved, from teletype to something that's high resolution probabilistic, are these, like, quantum leaps, in terms of warnings, for us?

Dr. WEAVER. Well, as my colleague just discussed, I think they are. What you're referencing is support for a program out of NOAA called FACETS. It's Forecasting A Continuum of Environmental Threats. So part of the support for that sprung up out of our Joplin tornado investigation. So, as I mentioned at the outset of my testimony, NWIRP is, at its core, a coordination program, and so, when we initiated that investigation, we invited a team member from NOAA to be on the team, and, as such, they played a role in creating the recommendations. And so one of the 16 recommendations out of that study was to develop technology for real time spatially tornado threat information. Now, the National Weather Service and NOAA were already engaged in that, but this investigation led to further support for that.

Mr. BEYER. Great. Thank you. General Tafanelli, I'm from Virginia, I know you were in the legislature in Kansas, so you understand local lawmaking really well. We're a Dillon State, which means local governments can't do anything the General Assembly doesn't specifically give them the ability to do. I know and understand that Kansas is a home rule State, so you have this issue where numerous rural jurisdictions don't have adopted building codes. How do you get them to do that when there's not a State mandate?

General TAFANELLI. Congressman, that's a great question. If I could've solved that, we wouldn't have some of those issues. What I would tell you is that I think what we do is provide information to those community leaders, to those county elected officials, so that they can see that data, and then they can make an informed decision for themselves, with respect to those adoptions of particular building codes.

Mr. BEYER. OK. I know most of our local jurisdictions in Virginia would rather be home rule, but no legislature's going to let that happen.

Dr. Weaver again, I'd never seen the phrase ephemeral data before. I had to look it up. How long does that typically last, this transitory data that NSF has the plan to investigate?

Dr. WEAVER. I'm sorry, I'm not sure I'm understanding your question.

Mr. BEYER. Well, you talked about the NWIRP coordination, including the NSF investment in 34 rapid response projects——

Dr. WEAVER. Sure.

Mr. BEYER [continuing]. On ephemeral data.

Dr. WEAVER. Yes. So those projects are integral to post-windstorm investigation. This is a situation where, when you have a disaster, oftentimes data starts to get lost. Things start to get picked up and cleaned up, and so these rapid proposals that NSF funds are very quick grants for university researchers to be able to go out and do reconnaissance missions as quickly as possible after the disaster strikes, and so the information that they gather

is critical to us understanding how the disaster unfolded, the impacts, and so the data that they provide are instrumental to that——

Mr. BEYER. Is this data that lasts a couple of days, or a couple of weeks?

Dr. WEAVER. No, they store it for the most part on something called Design Safe. And, actually, NIST does some wind mapping work where we store data on that entity, and folks can use that to correlate the disaster reconnaissance missions that they're doing, the things they're seeing with our wind mapping data.

Mr. BEYER. OK. Dr. Zuo, you talked about the Enhanced Fujita Scale. When almost all these tornadoes occur east of the Rocky Mountains, why did it get named after a Japanese scientist?

Dr. ZUO. Because Dr. Fujita was working at the University of Chicago, and he was very instrumental in developing the origin of Fujita scaled based on the damage to assess the wind speed. So his name got carried over when Texas Tech University developed the Enhanced Fujita Scale, because he's the first one. Thank you.

Mr. BEYER. As someone born abroad, and then comes here to do science, he probably won a Nobel Prize too, right?

Dr. ZUO. Unfortunately he didn't win a Nobel Prize, but he is very famous in this area.

Mr. BEYER. Yes. OK. Yes. Thank you very much. Madam Chair, I yield back.

Chairwoman STEVENS. Thank you. I would not recognize Mr. Babin for 5 minutes of questioning.

Mr. BABIN. Thank you, Madam Chair, and thank you, witnesses, for being here with your valuable insight and experience.

Dr. Zuo, I'm always glad to hear talk about scientific advances taking place in the State of Texas, especially when it comes to mitigating weather damage after Hurricane Harvey, which greatly impacted my district out of Houston, between Houston and Louisiana, with 60 inches of rain. As you mentioned, the National Wind Institute at Texas Tech University, where you are, supports research in atmospheric measurement and simulation, wind engineering, and energy systems. Could you discuss how the institute has collaborated with other academic institutions, especially those in the Tornado Alley region, along with Federal and industry partners on wind science research?

Dr. ZUO. Thank you very much, Congressman. This is a very good question. Texas Tech University does collaborate a lot with other institutions. For example, yesterday a researcher from University of Oklahoma National Weather Center was on campus to talk about their program, and explore how the National Wind Institute and the National Weather Center can work closer together to try to understand the storms. And we also have a joint wind engineering and science program with Florida International University, so it's under the National Science Foundation's Industry-University Cooperative Research Program. We work with industry to try to come up with solutions that can directly be applied by the industry patenters. So these are examples that we do——

Mr. BABIN. Excellent.

Dr. ZUO [continuing]. Work with some other centers. Thank you.

Mr. BABIN. Excellent. I was also impressed to learn that the EF Tornado Scale, the most accurate rating for tornadoes, and what we see printed in the news, was developed in 2007 at Texas Tech University, in collaboration with agencies and dozens of expert meteorologists. That's obviously a historical achievement that the Institute should be very proud of. Looking forward, what is the next big breakthrough in either atmospheric science or wind engineering, and, however ambitious it might be, what emerging idea do you get excited about in the future?

Dr. ZUO. Rating a tornado is a very complex problem. Right now everything is based on the damage, but every storm is different. Different storms can give you the same damage, especially in tornadoes, because tornadoes vary in size. Sometimes you have two tornadoes together. This structure can cause different damages.

The EF Scale, as you said, was developed in 2007, and much of it is based on understanding of the straight line wind, like the wind we experience every——

Mr. BABIN. Right.

Dr. ZUO [continuing]. Day, but not tornadoes. So right now people are able to simulate tornadoes in tornado simulators, like the one that we have at Texas Tech University. And they're also able to simulate tornadoes using numerical approaches, so understanding from these kind of studies can make the reading of tornadoes much more accurate.

Mr. BABIN. Aren't there instances and witnesses who have seen multiple vortices inside of a big F1 or F3 or F4 tornado? Is that not true?

Dr. ZUO. That is true. Sometimes you——

Mr. BABIN. Yes.

Dr. ZUO [continuing]. Do see multiple tornadoes within one small——

Mr. BABIN. Yes.

Dr. ZUO [continuing]. Area.

Mr. BABIN. Yes. Very strange. You mentioned two large wind tunnels that researchers have access to at the University of Florida and also Florida International University. I can safely assume those are more focused on hurricane wind hazards. What's the difference in hurricane hazard research and tornado hazard research, and is data from those experimental facilities useful for tornado research as well?

Dr. ZUO. Thank you, Congressman Babin, that's a very good question.

Mr. BABIN. Yes, sir.

Dr. ZUO. Actually, those facilities, as you said, are more suited for hurricanes, and, like cold fronts also. It's not for tornadoes, because tornadoes is a small-scale, swirling flow. It's not a straight line flow. So it changes the atmospheric pressure differently than hurricanes, and some other wind. So the data produced by those facilities can be used as a reference for the study of tornadoes, but not directly for the study of tornadoes.

Mr. BABIN. I've got you. Very interesting. The part of Texas that I represent, we have our share of tornadoes, but we're not in Tornado Alley, of course. We have the double benefit, or disadvantage, I should say, of hurricanes and tornadoes in our part of the State.

So thank you very much, and I appreciate every one of you, and I'll yield back, Madam Chair.

Chairwoman STEVENS. And now Mr. Tonko for 5 minutes of questioning.

Mr. TONKO. Thank you, Chairwoman Stevens, to you and Chairwoman Fletcher. Thank you for co-chairing what is a hearing on a very important topic, and thank you to the experts at the table for sharing your thoughts. New York has had a number of devastating natural disasters in recent years, including devastation from Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee. In New York's 20th District, my home district, we used to talk about storms that came once every 100 or every 500 years. This type of talk is no more with devastating weather events happening time and time again. The nomenclature has been proven totally off base. My hope is that the National Windstorm Impact Reduction Program will help better protect and prepare our communities.

And so, to both Dr. Weaver and Mr. Colker, you both discussed how property damage can be abated by improved building code. Can you tell us how the Impact Reduction Program agencies have worked together with the model building code community to develop newer building codes?

Dr. WEAVER. Sure. Thank you for the question, Congressman. So as I mentioned previously when we conduct our post-windstorm investigations, and I'm going to use the Joplin tornado as an example, but we also do hurricanes as well, out of the recommendations come some of the recommendations are for scientific improvements. In particular, with respect to that investigation, one of the recommendations was to improve or to develop tornado wind mapping to facilitate a design for tornado—for structures.

So that's the first ever of its kind, and so right now what we're trying to do is the science was developed to develop the wind maps for tornado design, first ever, and now our engineers are working with standards development organizations to get those implemented, for instance, into the American Society of Civil Engineers, into their 2022 update. It's a consensus process, so it's not something that will definitely occur, but we are working to implement that recommendation. So that would be an example.

Mr. TONKO. OK. Thank you. And, Mr. Colker, do you have anything that you want to add to that?

Mr. COLKER. Sure. The success of storm shelter implementation, I think, is one of those key areas that we can point to. So FEMA work on developing sort of the pre-requirements for storm shelters actually transitioned into Standard 500, which was then incorporated into the International Building Code, and International Residential Code, which is then applied at the State and local level.

In addition to just the standard itself, the NWIRP agencies and others work to get the requirement that storm shelters be in schools and emergency response facilities in vulnerable areas. And so, even taking that one step further, providing that safety to folks within communities. And, actually, New York is one of those communities that requires storm shelters within schools.

Mr. TONKO. Thank you. And, in regard to the improvement of building codes, what research would you cite, if any, is the most critical to get done right now? Is there any impact that you think

needs to be further researched that will provide protection out there?

Mr. COLKER. I mean, certainly the work that Dr. Weaver mentioned around tornado-specific design standards and risk maps I think would be incredibly valuable. Addressing the challenges of future risk, and how to incorporate those into building codes, is another essential area. And then I think also really understanding the interface of tornadoes and wind events in urban areas, I think, specifically would be helpful as well.

Mr. TONKO. And for anyone on the panel, strong and moderate building codes are generally cited as the most effective tool for limiting the impact of a natural disaster, and Mr. Colker mentions in his statement that the Code Council recently announced an initiative with code development organizations from Canada, Australia, and New Zealand. So how do model building codes in the United States compare to building codes in these other countries?

Mr. COLKER. I can certainly start. I mean, I think the biggest difference is actually the process that we use here in the United States. It's a consensus-based process, rather than a governmental-driven process, which many of these other countries have. In the developed world, I think we're generally comparable if we look sort of holistically across the codes. Certainly in, you know, in particular hazard areas, some, you know, countries may be a little more sophisticated, but I think overall we're probably generally about consistent with those more developed countries.

Mr. TONKO. Any others that wanted to respond to that, or—if not, I appreciate your response to my questions, and with that, yield back, Madam Chair.

Chairwoman STEVENS. Well, thank you all. And before we bring the hearing to a close, we certainly want to recognize our witnesses again for your expertise and your time. This is a really terrific hearing, and certainly explains a little bit more about the complexities and difficulties of navigating within the built environment, and the costs that are incurred, but also the opportunities before us. So we're all better off because we got to spend time with each of you today.

Our record's going to remain open for 2 additional weeks for additional statements from Members, or for questions that they may have of the witnesses. And, at this time, our witnesses are excused, and our hearing is now adjourned.

[Whereupon, at 4:10 p.m., the Subcommittees were adjourned.]

# Appendix I

## Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

*Responses by Dr. Scott Weaver*

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY SUBCOMMITTEE ON ENVIRONMENT

"Calm Before the Storm: Reauthorizing the National Windstorm Impact Reduction Program"

Questions for the Record to: Dr. Scott Weaver
Director, National Windstorm Impact Reduction Program National Institute of Standards and Technology Submitted by Ranking Member Jim Baird

1. When NIST conducts an investigation, like they did after the Joplin tornado of 2011 and they are currently conducting following Hurricane Maria in Puerto Rico, how are the other program agencies (FEMA, NOAA, NSF) incorporated into investigation recommendations?

**NIST Response**: Development of NIST recommendations following post-windstorm investigations typically involves other National Windstorm Impact Reduction Program (NWIRP) agencies in two ways: direct partnership during the investigation and coordination on the implementation of recommendations following the final report.

- First, FEMA, NOAA, and NSF share relevant data from research teams, information about research plans and programs, and personnel or grantees who coordinate with or participate alongside NIST team members. These three activities leverage federal resources to enhance the investigation findings and maximize the potential to develop effective recommendations. These efforts are consistent with NWIRP authorizing language to "coordinate all Federal post-windstorm investigations to the extent practicable."
- Second, depending on how a particular recommendation aligns with mission and authorities, the lead organization for recommendations may be other NWIRP program agencies. For example, FEMA, NOAA were responsible for the implementation certain recommendations resulting from the National Construction Safety Team Technical Investigation of the May 22, 2011, Tornado in Joplin, Missouri. And NSF, which has a basic research mission rather than an operational one, has supported academic research and research infrastructure that aligns with the recommendations. The rigor and quality of the investigation report(s) combined with the standing of partner agencies with their stakeholder communities, results in a high likelihood of success in implementing recommendations.

a. You mentioned a team member from NOAA' s National Severe Storms Laboratory served on the investigative team and facilitated the implementation of a recommendation in the Joplin report. Is this common? Are all team members required, or encouraged, to give a recommendation in their area of expertise?

**NIST Response**: The National Construction Safety Team Act (2002) requires that teams shall include at least one employee of NIST and shall include other experts who are not employees of NIST, which may include private sector experts, university experts, representatives of

professional organizations with appropriate expertise, and appropriate federal, state, or local officials. Each team member is encouraged to take a proactive role within the team and to provide extensive input on the final recommendations.

2. We've talked a lot about collaboration and information sharing when it comes to protecting key infrastructure such as homes, businesses, etc. But given my background and the large impact agriculture has in my district, are any efforts being made to explore and test ideas to mitigate crop loss, top soil erosion, and other effects windstorms can have on the agricultural community?

**NIST Response**: According to the NWIRP Reauthorization of 2015, the purpose of NWIRP "is to achieve major measurable reductions in the losses of life and property from windstorms through a coordinated Federal effort." Consequently, the current focus of the program is on wind impacts on the built environment. USDA has a number of programs that consider the impacts of windstorms on agriculture; NIST frequently collaborates with other federal agencies under NWIRP and welcomes opportunities to do so.

*Responses by Major General Lee Tafanelli*

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT

Questions for the Record to:
Major General Lee Tafanelli
Adjutant General of Kansas
Director, Kansas Homeland Security
Director, Emergency Management
**Submitted by Ranking Member Jim Baird**

1. We've talked a lot about collaboration and information sharing when it comes to protecting key infrastructure such as homes, businesses, etc. But given my background and the large impact agriculture has in my district, are any efforts being made to explore and test ideas to mitigate crop loss, top soil erosion, and other effects windstorms can have on the agricultural community?

**DEPARTMENTS OF THE ARMY AND THE AIR FORCE**
HEADQUARTERS KANSAS NATIONAL GUARD
2722 SOUTHWEST TOPEKA BOULEVARD
TOPEKA, KS 66611-1287

9 January 2020

Congressman Jim Baird
2321 Rayburn HOB
Washington, DC 20515

Dear Congressman Baird:

Thank you for the opportunity to testify on behalf of the State of Kansas on December 4, 2019 during the Subcommittee on Research and Technology and Subcommittee on Environment hearing on the "Calm Before the Storm: Reauthorizing the National Windstorm Impact Reduction Program." Below you will find my response to your question for the record.

Agriculture is a substantial industry within the State of Kansas and the mitigation of soil erosion is important to the State as it is capable of impacting our economy and the livelihood of Kansas citizens. There are several factors that lead to soil erosion like wind, floods, and drought. Mitigation against flooding is actively performed within Kansas utilizing FEMA Hazard Mitigation Assistance (HMA) funding, however FEMA HMA funding is ineligible for use in mitigation against soil erosion due to windstorms. This has led to limited windstorm soil erosion mitigation efforts in States impacted by windstorms such as Kansas.

State program partners, such as the Kansas Department of Agriculture's Division of Conservation, support efforts to mitigate against top soil erosion through financial incentives educational campaigns, often in coordination with USDA's Natural Resources and Conservation Service. Crop producers have experienced some success combating soil erosion through crop rotation, cover crops, field resting, and wind breaks. The Kansas Division of Emergency Management actively entertains proposals for mitigation projects aimed at reducing crop impacts, however projects that require additional funding to implement are limited to those eligible within FEMA guidance.

Should you require any additional information, please contact Major Martin Schimmele at martin.l.schimmele.mil@mail.mil or by phone at 785-646-0011.

Sincerely,

Lee E. Tafanelli
Major General, KSNG
The Adjutant General

## *Responses by Dr. Delong Zuo*

**Question by Ranking Member Jim Baird**

We've talked a lot about collaboration and information sharing when it comes to protecting key infrastructure such as homes, business, etc. But given my background and the large impact agriculture in my district, are any efforts being made to explore and test ideas to mitigate crop loss, topsoil erosion and other effects windstorms can have on the agriculture community?

**Answer by Delong Zuo, Associate Professor of Civil Engineering, National Wind Institute, Texas ZTech University**

Thanks Congressman Baird for the question. I understand that windstorms can have significant impact on the agriculture community. As you suggested, windstorms can damage large areas of crops and result in topsoil loss. They can also cause failures of agriculture infrastructure such as Irrigation Structures. All these can result in substantial financial losses. However, upon receiving this question, I didn't know of any research that had been conducted to directly study the impact of windstorms on the agriculture community. I was indeed aware, however, that there have been some studies on the effects of windstorms that are indirectly related to the agriculture community. For example, there have been studies that attempted to estimate tornado wind speeds based on the falling pattern of vegetations in tornadoes. There have also been initiatives to use observed damages to Center-Pivot Irrigation Structures as indicators in the estimation of tornado EF-scales. I have since done some researching to see if I have missed studies of tornado impact on the agriculture community because my area of research is primarily on wind effects on civil infrastructures. However, I was not able to find research that directly address this problem.

I think the lack of studies on the impact of windstorms on the agriculture community is perhaps a result of the catastrophic damages these storms can inflict on the built environment and the perception that those damages are more dramatic and impactful than the damages to crops and the agriculture infrastructure. In addition, the uncertainties involved in the effects of windstorms on crops perhaps also give researchers the impression that the problem involving crops is less trackable than that involving civil infrastructure. I think you have raised an excellent question. I do believe that the impact of windstorms on the agriculture community can be significant and that it should be studied in the future.

*Responses by Mr. Ryan Colker*

RESPONSE TO QUESTIONS FOR THE RECORD

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEES ON RESEARCH AND TECHNOLOGY AND ENVIRONMENT

"CALM BEFORE THE STORM: REAUTHORIZING THE NATIONAL WINDSTORM IMPACT REDUCTION PROGRAM"

JANUARY 9, 2020

RYAN M. COLKER, J.D., CAE

VICE PRESIDENT, INNOVATION, INTERNATIONAL CODE COUNCIL

EXECUTIVE DIRECTOR, ALLIANCE FOR NATIONAL & COMMUNITY RESILIENCE

Thank you for the distinct honor to testify before the Research and Technology and Environment Subcommittees at the December 4, 2019 hearing on "Calm Before the Storm: Reauthorizing the National Windstorm Impact Reduction Program." I am pleased to provide this response to Ranking Member Baird's Question for the Record and to provide additional detail in response to Representative Tonko's question during the hearing.

**Response to Ranking Member Baird**

*We've talked a lot about collaboration and information sharing when it comes to protecting key infrastructure such as homes, businesses, etc. But given my background and the large impact agriculture has in my district, are any efforts being made to explore and test ideas to mitigate crop loss, top soil erosion, and other effects windstorms can have on the agricultural community?*

In many communities, agriculture serves as the backbone of the economy. Additionally, the nation as a whole relies on the agricultural products produced in these communities. Protecting the community and agricultural processes from windstorm impacts is essential for social, economic and infrastructural resilience. While the International Code Council's expertise does not extend to agricultural processes, our codes, standards and other industry solutions certainly support the resilience of the infrastructure that agricultural economy relies on.

For example, the International Codes (I-Codes) developed by the Code Council provide criteria to protect occupant safety and efficiency across the entire agricultural supply chain. Based on the level of hazard and the occupancy types, the I-Codes include provisions specifically applicable to agricultural buildings including barns, grain silos, livestock shelters, stables and greenhouses. Like all buildings covered by the I-Codes, these provisions are intended to limit the impacts from windstorm events.

Adoption and enforcement of the I-Codes in agricultural communities provides a level of resilience and protection of the agricultural process and the community's livelihood. Research on the impacts of

windstorms on the agriculture and the development of best practices to reduce those impacts would be beneficial to agricultural communities. As Congress considers reauthorization of NWIRP, it may consider including a charge to address agricultural issues through the engagement of relevant federal agencies and stakeholders including the U.S. Department of Agriculture (through the Rural Development Program, the Agricultural Research Service, and the Natural Resources Conservation Service).

**Response to Representative Tonko**

Representative Tonko asked about the comparison of model building codes in the United States to those in other countries. I'm pleased to provide more clarity and detail here by way of a potential substitution to my response contained in the transcript.

"The model codes developed in the United States are leading the world in achievement of safe and efficient buildings while remaining highly cost effective. This is largely attributable to the unique process where the I-Codes are developed in the private sector through an open, consensus process that brings together expertise from across the public and private sectors. Most other countries have a government driven process that includes less engagement from the private sector, and that provides less frequent updates, making it less responsive to changing practices, new technologies and new research. Even among those countries that do permit private sector involvement, the United States is a leader—our codes are updated on three-year cycle, while Europe's building codes are currently being updated for the first time since 2007.

Another considerable benefit of the U.S. model pertains to application of the adopted codes in the field. Ensuring codes are properly administered and enforced at the local level provides an additional loss reduction value on the order of 15 to 25 percent beyond the design benefits the code provides according to a study by Czajkowski et.al. The effective application and enforcement of building codes includes effective training and certification of code officials, design professionals, and service providers (contractors, plumbers, etc.), as well as developing a system of enforcement that includes, at a minimum, the evaluation of building materials for compliance with codes and standards, and accreditation of testing laboratories, fabricators, and building departments. The Code Council provides communities with the entire ecosystem of services that support the application and enforcement of building safety requirements. According to the World Bank Building Regulation for Resilience Program, which works extensively in developing countries using a variety of model codes, "there is no other code developing organization like the International Code Council that can provide training resources for the last mile in applying the theory of the building code to the practice of construction."

# Appendix II

## Additional Material for the Record

LETTERS SUBMITTED BY REPRESENTATIVE HALEY STEVENS

Washington Office
25 Massachusetts Avenue, NW
Suite 500
Washington, D.C. 20001
(202) 789-7850
Web: http://www.asce.org

December 3, 2019

The Honorable Lizzie Fletcher
Chair
Subcommittee on the Environment
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, DC 20515

The Honorable Haley Stevens
Chair
Subcommittee on the Research and Technology
Committee on Science, Space and Technology
U.S House of Representatives
Washington, DC 20515

The Honorable Roger Marshall
Ranking Member
Subcommittee on the Environment
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, DC 20515

The Honorable Jim Baird
Ranking Member
Subcommittee on Research and Technology
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Chairs Fletcher and Stevens and Ranking Members Marshall and Baird:

On behalf of the American Society of Civil Engineers (ASCE), I would like to thank you for holding this important hearing on reauthorization of the National Windstorm Impact Reduction Reauthorization Program (NWIRP). Your continued leadership on this important issue is greatly appreciated by the civil engineering community.

ASCE would like to thank the Subcommittees for inviting Dr. Delong Zuo of Texas Tech University to testify at the hearing. ASCE is pleased to offer our support for his testimony.

ASCE was instrumental in the creation of NWIRP in 2004 and stands ready to offer any assistance we can to you and to other members of Congress in ensuring the continuation of the critical program. ASCE is firmly convinced that a unified, well-funded national program addressing efficient wind-resistant design and construction, early warning and detection, improved emergency response, and public education and awareness will result in a significant reduction in losses, both human and economic.

ASCE is pleased with the progress that the agencies involved with NWIRP have been able to make with the limited resources available to them. We are concerned that NWIRP is not meeting their mitigation goals for wind related damage following a

windstorm event and believe this should be an important area of focus for the program. Additionally, it is part of the NWIRP Strategic Plan to develop a retrofit standard for wind effects however, NWIRP has not had the funding available to perform this important task. Again, this is another area where Congressional support could help produce critical progress.

It is also important to note that the research being done through the NWIRP provides vital technical input to the development of ASCE 7 Wind Load Provisions and other standards that ASCE produces. ASCE 7 is the accredited, consensus-based engineering standard that is the primary reference of structural design requirements in all U.S. building codes.

Please do not hesitate to call on ASCE to provide technical information and outreach to colleagues. As the organization representing the profession most responsible for the nation's public works infrastructure and built environment, ASCE is well positioned to support your efforts. Additionally, ASCE is ready to call on the expertise of our fellow engineering and scientific colleagues as needed.

Please contact Martin Hight, ASCE's Senior Manager of Government Relations at 202-789-7843 or mhight@asce.org if we can be of more assistance. Once again, thank you for your continuing leadership on this important issue.

**Sincerely,**

K.N. Gunalan, Ph.D., P.E., D.GE, F.ASCE
ASCE President 2020

***Calm Before the Storm:***
***Reauthorizing the National Windstorm Impact Reduction Program***
**House Committee on Science, Space and Technology**
**United States House of Representatives**
**December 4, 2019**

**Comments for the Record**

**Ioannis Zisis, Ph.D.**
**Co-Director for Wind Hazard Infrastructure Performance (WHIP)**
**Industry–University Cooperative Research Center Program**
**&**
**Richard Olson, Ph.D.**
**Director, Extreme Events Institute**
**Florida International University**

Florida International University (FIU) thanks Chairwoman Eddie Bernice Johnson, Ranking Member Frank Lucas, and the Members of the House Science, Space, and Technology for taking a lead on the reauthorization of the National Windstorm Impact Reduction Act, such a crucial cause for our country's resilience efforts. We hope to take this opportunity to share some of observations derived from some of our own research on windstorm impacts, building sciences and effective mitigation strategies. FIU and our researchers also extend our support as a resource as the Committee works through reauthorizing this act.

Founded in 1965, Florida International University is Miami's public research university and is focused on student success and research excellence. Ranked as a top-tier, R-1 research university by Carnegie's Classification of Institutions of Higher Education with nearly $225 million in annual research activity, our faculty researchers and students are addressing some of the greatest challenges of our time. In particular, we are proud of our decades-long collaboration with most relevant federal agencies on disaster-related research.

We are committed to high-quality teaching, state-of-the-art research, creative activity, and collaborative engagement with our local and global communities as we support our 58,000 students and over 250,000 alumni.

The **Extreme Events Institute (EEI) at FIU** is at the forefront of disaster resilience and risk mitigation. FIU's facilities and researchers leverage the strengths of many of our colleges and schools to build greater capacity for society in disaster mitigation which also allows for the improvement to our nation's resilience. EEI has enabled a flexible team-building approach to research on hazards, exposures, vulnerabilities, and risk.

We wish to highlight observations derived from two specific federally-granted collaborative centers within the Extreme Events Institute for the Committee to consider. Both the **Industry University Cooperative Research Center (IUCRC) on Wind Hazard and Infrastructure Performance (WHIP)** and the **Natural Hazard Engineering Research Infrastructure (NHERI)** program utilize the Wall of Wind and conduct research for federal partners and the building industry.

The WHIP Center, which is funded by the National Science Foundation (NSF) and industry partners is co-led by FIU and Texas Tech University and works to pursue research to enhance resiliency of buildings and infrastructure to resist extreme winds of hurricanes, tornadoes, and other windstorms. The principal research themes are assessment of wind hazards, estimation of exposure and vulnerability of buildings and infrastructures, and improvement of community resilience.

The Wall of Wind is a testing facility that was selected by NSF as one of only nine experimental facilities under the Natural Hazard Engineering Research Infrastructure (NHERI) program. NHERI enables research and educational advances that can contribute knowledge and innovation for the nation's civil infrastructure and communities to prevent natural hazard events from becoming societal disasters.

**Recommendations to Consider**

The impacts of the research initiatives led by FIU are instructive for the Committee to consider as it develops a new authorization bill. It is our belief that Congress has an opportunity in a future National Windstorm Impact Reduction Act to prioritize:

- **Greater emphasis on multi-hazard solutions** – Research efforts not only need to consider multiple hazards (wind, rain, storm-surge, earthquake, tsunami etc.) but most importantly their combined or cascading effect.
- **Category 5+ storms** – Although the Saffir-Simpson wind scale for hurricanes as yet does not have a Category 6, there is evidence for increasing numbers of stronger storms, which requires more high-speed testing of designs, structures, and building components.
- **Real world building performance** – Pre- and post-event monitoring of instrumented buildings can provide invaluable information. The response and performance of structures and building components during actual extreme events will generate the necessary knowledge that will improve simulation and laboratory test efforts.
- **Rapid knowledge transfer to industry and policymakers** – The research output should be able to reach efficiently stakeholders and policy makers. This includes building code and standard committees, industry partners (e.g. mitigation and retrofit products) and innovation funding sources.
- **Multi-disciplinary research, including studying social vulnerability** – Real life impacts of windstorms tell a story that goes past damage to buildings and other materials. Multiple disciplines need to work together and produce complete solutions for people and communities.
- **Efficient and effective funding plans, including increased extramural research to the nation's research universities** – Increasing extramural funding from agencies like NIST and the NSF need to reach academic research centers. Incentives for industry-academia collaborations are critical and should be promoted.

Florida International University thanks the Committee for taking the time to consider our recommendations for the National Windstorm Impact Reduction Act Reauthorization. As the House Science, Space, and Technology Committee works to finalize the reauthorization, please consider FIU as a resource for any questions that may arise.



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