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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 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

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

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 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.