

**National Construction Safety Team  
Advisory Committee (NCSTAC) Meeting Summary**

**National Institute of Standards and Technology (NIST)  
Gaithersburg, Maryland**

**August 30, 2018**

**NCST Advisory Committee Members:**

James Harris	Committee Chair, J.R. Harris and Company,
Ross Corotis	University of Colorado, Boulder
Reginald DesRoches	Committee Vice Chair, Rice University
William Holmes	Rutherford + Chekene
Gary Klein	Wiss, Janney, Elstner Associates, Inc.
Jeanette Sutton	University of Kentucky

**NIST Staff and Guest Speaker(s):**

Jason Averill	Chief, Materials and Structural Systems Division, NIST
Jason Boehm	Director, Program Coordination Office, NIST
Ben Davis	Management and Program Analyst, NIST
Howard Harary	Director, Engineering Lab; Designated Federal Officer, NIST
Ken Harrison	Community Resilience Group, NIST
Thomas Kirsch	National Center for Disaster Medicine and Public Health, DOD
Erica Kuligowski	Research Social Scientist, NIST
Marc Levitan	Research Wind Engineer, Structures Group, NIST
Joseph Main	Research Structural Engineer, NIST
Judith Mitrani-Reiser	Director, Disaster and Failure Studies Program, NIST
Michael Newman	Public Affairs Office, NIST
Long Phan	Leader, Structures Group, NIST
Scott Weaver	Director, National Windstorm Impact Reduction Program, NIST

## **I. Opening Remarks**

### ***Call to Order and Roll Call***

Dr. Judith Mitrani-Reiser opened the meeting. Committee members, NIST staff, and other attendees introduced themselves. Following a review of emergency exit procedures, Dr. Mitrani-Reiser introduced Dr. Jason Boehm, who provided opening remarks.

### ***Welcome and Opening Remarks***

Dr. Jason Boehm spoke on behalf of Dr. Walt Copan, who was attending the National Conference of Standards Laboratories International meeting in Portland, Oregon.

Dr. Boehm welcomed Mr. William Holmes (the newest member of the NCST Advisory Committee) and provided a brief background of his expertise. Mr. Holmes has over 45 years of experience in all aspects of structural design and is a Senior Consultant at Rutherford + Chekene.

Dr. Boehm briefly introduced the Hurricane Maria NCST technical investigation, which is focused on characterizing the wind environment and technical considerations associated with deaths and injuries, the performance of emergency communication systems, and the public's response to those communications, as well as the performance of representative critical buildings and designated safe areas in Puerto Rico. Dr. Boehm emphasized that this is the first-ever NCST investigation of a hurricane, and that the findings will result in recommendations to improve building standards, codes, and practices.

Sixteen recommendations were made from the results of the NCST investigation of the Joplin tornado that occurred on May 22, 2011. The implementation of these recommendations requires a sustained commitment from NIST staff, partner agencies, the private sector, and community organizations.

### ***Meeting Goals and Review of Agenda***

NCSTAC Chair, Dr. James Harris, stated that the goals of the meeting are to review progress on the implementation of recommendations from NIST's NCST investigation of the Joplin tornado, review progress on the NCST investigation of Hurricane Maria's effects on Puerto Rico, provide recommendations to NIST that will better prepare the readiness of future National Construction Safety Teams to carry out effective and impactful disaster and failure investigations, and develop the annual report to Congress.

## **II. [NIST Response to the NCSTAC's 2017 Report to Congress](#)**

Dr. Howard Harary gave a brief review of all the NCST investigations undertaken by NIST. The NCST Act authorizes the NIST Director to establish Teams for deployment after events, which are charged with the following:

- establish likely technical cause(s) of building failure
- evaluate technical aspects of evacuation and emergency response procedures
- recommend improvements to building standards, codes, and practices

- recommend research and appropriate actions needed to improve the structural safety of buildings and improve evacuation and emergency response procedures

The NCST Advisory Committee has a responsibility to submit a report to two congressional committees by January 1<sup>st</sup> of each year. This report includes an evaluation of Team activities and recommendations to improve the effectiveness of the Team, as well as an assessment of the implementation of recommendations from previous NCST investigations.

Dr. Harary provided the following requirements of the current NCSTAC Charter:

- meet at least once per year either in person, via telephone conference calls, or videoconferences;
- hold additional meetings, if requested by the NIST Director or the DFO (Designated Federal Official);
- review and support the development of recommendations that result from NCST investigations; and
- submit an annual report to Congress by January 1<sup>st</sup> of each year that includes an evaluation of NIST's implementation of the NCST Act and an assessment of the implementation of NCST recommendations.

Dr. Harary noted that subcommittees could be formed within the NCSTAC, but they would need to report back to the entire NCSTAC and could not provide consensus advice. Consensus advice can only be provided by the entire NCSTAC.

Dr. Harary provided the following NIST responses to the recommendations raised by the NCSTAC in their FY2017 report:

### ***1. NCST Investigation Funds***

One recommendation offered by the NCSTAC is that funds should be specifically allocated to investigations when disasters are declared. The concept of dedicated reserve funds remains under evaluation. NIST remains on a year-to-year budget. The NIST Director, who follows the investigations closely, has provided internal supplemental funding to kick off team investigations of disasters, including the current NCST Hurricane Maria Investigation. External supplemental funding was provided for the NCST investigations of the World Trade Center and the Station Nightclub Fire in Rhode Island. However, solely internal funding was provided by the Engineering Laboratory for the NCST investigation of the Joplin Tornado.

### ***2. Economic and Design Factors***

The Committee recommended that NIST stay involved in the codes and standards process and be thoughtful of the economic and design factors involved in implementing an NCST investigation's recommendations. As an agency of the Department of Commerce, NIST has a responsibility to ensure that their research has feasible applications in design and construction industries. An appreciation of economic factors of research and science is crucial for future adoption by industry. In past NCST investigations, NIST has performed cost-benefit analyses of recommendations. Additionally, NIST can request that design and economic feasibility be

considered during the public comment period after NCST investigation reports are first released, as they have done in the past. NIST has included an applied economist on the team for the current Hurricane Maria NCST investigation to ensure the costs and benefits of recommendations are being considered throughout the investigation.

### ***3. Further Studies of Emergency Communications***

The Committee also recommended that NIST further study the communication of alerts and warnings during imminent threats. The Committee recommended the additional analysis of the presence or absence of communication strategies used to reach populations at risk, including mechanisms and technology to help make decisions about protective actions (i.e., evacuating or sheltering in place). NIST has studied alerts, messaging, and people movement in all of its prior NCST investigations. It is explicitly included in one of the Hurricane Maria investigative goals to assess the use of communications in disaster response during and immediately after an event.

*Dr. Sutton asked a clarifying question of Dr. Harary on whether this investigative goal includes alert providers in the use of communications. Dr. Harary replied that alert providers are included in the use of communications for the Hurricane Maria NCST investigation.*

### ***4. Economic Analysis of Recommendations***

The Committee raised a recommendation from a prior report, that critical infrastructure (i.e., hospitals and emergency operation centers) be designed to remain operational and that the benefits and costs associated with design criteria need further examination. NIST has performed cost-benefit analyses on previous recommendations and strive to continue developing feasible recommendations in current and future NCST investigations. As already mentioned, NIST has included an applied economist on the team for the current Hurricane Maria NCST investigation to ensure the costs and benefits of recommendations are being considered throughout the investigation. The Engineering Laboratory's Applied Economics Office is a resource that will benefit this effort. Any recommendations resulting from investigations that require changes to codes need to go through a consensus process, which involves more constituents and can be extremely challenging. There are several complicated factors involved that have not had a systematic analysis conducted by the industry; research done in this area could have widespread application for building codes and standards. NIST welcomed comments from the Committee regarding the feasibility of their recommendations.

*Dr. Harris commended NIST for including an economist at the beginning of the study.*

### ***5. Social and Behavioral Science***

The Committee recognized that NIST's social and behavioral scientists are developing technical and scientific knowledge about risk, such as hazard maps and damage indicators. The Committee recommended that NIST include in their products appropriate scientific terms that can be understood by community officials and the general public, which will help reach vulnerable populations. NIST purposefully includes social and behavioral scientists in NCST investigations; three social and behavioral scientists are involved in the current Hurricane Maria NCST investigation. The development of appropriate terms that can be understood by community

officials and the general public in translating knowledge about risk in briefings, documents, and recommendations is underway.

### ***Committee Discussion of NIST's Response to the NCSTAC's FY2017 Report to Congress***

*Dr. Sutton asked about the level of effort required in the translation of scientific terms of NIST product. Dr. Harary replied that this is an ongoing effort, and that the Hurricane Maria investigation of impacts in Puerto Rico necessitated translation of English into Spanish, and vice versa. One Team member is a fluent Spanish speaker, and others are currently taking Spanish lessons to facilitate the investigation. The lead of the Hurricane Maria NCST investigation, Dr. Erica Kuligowski, replied that a contract will be awarded to cover any translation needs that may arise. All of the reports produced as a result of the current NCST investigation will be translated into Spanish.*

*Mr. Gary Klein asked if the materials used in preparation for their letter (annual report) to Congress, will be available to the NCST or on the website? Dr. Harary replied that all supporting documentation is available to the Hurricane Maria NCST, the Committee, and to the public.*

### **III. Summary of Progress on Implementation of the Joplin Tornado Recommendations**

Dr. Long Phan provided an update on progress made on the implementation of the recommendations from the NCST Joplin Tornado Investigation. NIST developed a set of 16 draft recommendations and categorized them into three groups:

- Group 1: Hazard Characteristics
- Group 2: Buildings, Shelters, Designated Safe Areas, and Lifelines
- Group 3: Emergency Communication

Dr. Phan highlighted specific recommendations in his summary. In Group 1, Recommendation 2 calls for making available to the public a tornado database and Recommendation 4 calls for improvement of the Enhanced Fujita (EF) scale. Also under Group 1, a committee was formed with the American Society of Civil Engineers (ASCE) and the American Meteorological Society (AMS) on developing the standard wind speed estimation for tornadoes and other windstorms; a second stakeholder workshop will take place at ASCE headquarters in early 2019 to get feedback from the codes and standards community on progress to date of the tornado hazard maps. In Group 2 and as part of Recommendations 5 and 6, NIST is leading the new ASCE Tornado Task Committee charged with developing tornado load provisions for ASCE 7-22. In Group 3 and as part of Recommendation 13, NIST published technical notes on alerting guidance and proposed the incorporation of this guidance into the National Fire Protection Association (NFPA) 1600 standard. In addition, NIST's Disaster Resilience Grants Program funded research focused on the development of tornado design criteria for buildings and shelters subject to tornado-induced loads. This project aims to capture key insights on tornado-induced pressures (including atmospheric pressure change) and develop: (1) fragilities that relate tornado wind speed to the probability of damage, and (2) recommended loads for tornado-resistant design.

## [Tornado Hazard Characteristics: Performance of Buildings, Shelters, Designated Safe Areas, and Lifelines](#)

Dr. Marc Levitan provided more details on some of the recommendations over all three Groups.

Dr. Levitan stated that The NIST Disaster Resilience Grants Program would be used to support the implementation of **Recommendation 1**: development and deployment of instrumentation systems that can measure and characterize actual tornadic near-surface wind fields, for use in the engineering design of buildings and infrastructure. Awards made under this program will support research on the development of new sensors and methods to collect spatiotemporal data on windstorm phenomena, including surface-level winds and near-ground velocity profiles, and atmospheric pressures.

In order to improve publicly available tornado databases (**Recommendation 2**), NIST has been actively working with NOAA (National Oceanic and Atmospheric Administration) on the following activities:

- developing a tornado database structure and improvements on data collection procedures with the National Weather Service (NWS) and Storm Prediction Center (SPC),
- improving the Storm Data application and database with the NWS Performance Branch,
- improving data archival procedures and ease of access to data with the National Centers for Environmental Information (NCEI), and
- developing an annex to the National Plan for Disaster Impacts and Assessments (NPDIA) on wind and water data related to tornadoes and other windstorms with the Office of the Federal Coordinator for Meteorological Research and Support Services (OFCM).

In terms of progress on tornado hazard maps (**Recommendation 3**), Dr. Levitan described NIST's activities on extended tornado regionalization schemes to also handle sub-regional variations. There has been a finalization on the approach to handle population bias. An approach has been developed for explicit consideration of mapping uncertainties, which will identify seven main components of tornado wind speed risk. Planning is ongoing for the second tornado mapping stakeholder workshop, which will occur in early 2019. On the tornado map development process, NIST is four years into a five-year effort. The following factors have been incorporated into the tornado maps in order to produce more accurate data:

- The EF scale distribution of tornadoes previously classified all tornadoes with unknown densities as "EF-0." This polluted the database. New guidance now allows these tornadoes to be labeled as "EF-unknown."
- Population bias studies which look at areas with a high density of buildings, basically urban areas with large densities as the baseline. This illustrates that more tornadoes are reported in areas of high building density, and that there is a greater chance that the tornado has something to hit.
- Broad tornado regions have been used to provide the starting point for analyses and reflect the variation of tornado climatology across the United States, using reported historical data. The regionalization scheme started out with storm prediction data. The CLUSTER procedure from the SAS/STAT module was used to identify areas with similar tornado risk metrics.

Dr. Levitan described the development of the Enhanced Fujita (EF) Scale after post-storm damage survey of the Jarrell Tornado of May 27, 1997 in Texas. This study led to NIST funding work at Texas Tech University to create the EF scale, which NOAA adopted in 2007. NIST is currently working on improving the Enhanced Fujita Scale (**Recommendation 4**) with the addition of damage indicators, particularly those

that better distinguish between the most intense tornado events. An ASCE/SEI/AMS standard on wind speed estimation in tornadoes and other windstorms is under development; this work will entail a new approach to assigning wind speeds for each degree of damage for all damage indicators in the EF scale, based on the qualitative assessment of resistance. Additionally, NIST is building a detailed database of residential tornado damage, which will enable significant improvements to the damage indicators for one- and two-family homes.

As part of **Recommendations 5 and 6**, focused on the development of performance-based standards for tornado-resistant design, NIST chairs the new ASCE 7-22 Wind Load Subcommittee. The first meeting of this Committee was held on January 2018 and will meet again in approximately six months. The following areas expected to be covered at the next meeting are: developing tornado maps for existing return periods used in ASCE 7, developing tornado maps and load provisions, and developing higher return period non-tornadic wind speed maps.

In response to **Recommendation 7a** to develop a tornado shelter standard for existing buildings, NIST and the Federal Emergency Management Agency (FEMA) collaborated on the submission of a number of proposals to the International Code Council (ICC) 500-2020 standard during the public comment period. Additionally, NIST personnel (Dr. Levitan), will be chairing the ICC 500 Committee. NIST also partnered with FEMA, NOAA, and the University of Oklahoma to hold a public workshop on tornado sheltering at the National Tornado Summit on March 4, 2019.

**Recommendation 8** emphasized the need for developing and implementing uniform national guidelines that enable communities to create safe, effective public sheltering strategies. The public workshop on tornado sheltering at the National Tornado Summit will also focus on communications, challenges, best practices, and shelter operations; this effort is possible via a collaboration with FEMA and NOAA's Storm Prediction Center and the National Severe Storms Laboratory. Areas of discussion will include whether recommendations need to be made for people to shelter in place or go to public tornado shelters.

In response to **Recommendation 10**, focused on the prohibition of using aggregate as surfacing for roof coverings on buildings in tornado-prone region, NIST developed a code change proposal for the 2018 International Building Code (IBC). The code change proposal banned loose aggregate, gravel, and stone surfacing and ballast on roofs, and would impact less than one percent of all roof construction. The proposal to change the code regarding banning loose aggregate was not successful. NIST is planning to resubmit the code change proposal to the 2021 International Building Code and will include research by NIST's Applied Economics Office that shows negligible cost impact due to the suggested code change.

NIST has made significant contributions to implement **Recommendation 13**, focused on the development of national codes, standards, and guidance for clear, consistent, recognizable, and accurate emergency communications. One of the goals of the public workshop at the National Tornado Summit is to capture information on challenges, research needs, solutions, and best practices, including the development of a joint plan by emergency managers, the media, and the NWS for consistent alerts. Emergency communications progress is ongoing for the development of guidance for community-wide public alerts in emergencies, such as wireless emergency alerts and Twitter. The NIST [Technical Note 2008 Alerting under Imminent Threat: Guidance on alerts issued by an outdoor siren and short message alerting systems](#) publication provides background on alerting systems and discusses the methods for developing the guidance. Additionally, NIST has developed new short message templates with a 280-character limit for Twitter and 360-character limit for Wireless Emergency Alerts (WEA) messages. These templates were

presented at the Natural Hazards Research Application Workshop in Colorado are currently under review in a peer-reviewed journal. NIST has also proposed the incorporation of this messaging guidance into NFPA 1600. The next edition of the standard is currently open for notice of intent to make a motion and will close on August 30<sup>th</sup>, 2018.

***Committee Discussion of Progress on Joplin Recommendations:***

*Mr. Klein asked if NIST was interacting with the International Residential Code (IRC), which controls all housing codes in the country, to assist in the progress of having the NIST proposed codes adopted. Dr. Levitan responded that NIST has not yet interacted with the IRC. Dr. Levitan clarified that NIST is currently working with the ASCE 7 standard (2022 edition), and will later work with IBC, and IRC 2024. NIST ensured they will work with ASCE and other stakeholders to get the appropriate language into the 2024 version of those codes.*

*Dr. Harris asked about the economic impact on a construction site and aggregate material flying off buildings and why this effort has not been successful to date. Dr. Phan clarified there is a current ban on roof surface aggregate in hurricane-prone regions. Dr. Levitan added that NIST reached out to the roofing industry before submitting the code change proposals, but they have provided little-to-no input. NIST has also reached out to the National Council on Structural Engineering Associations (NCSEA) for guidance to help with the new code development.*

*Dr. Harris asked if the roofing industry had any data or reasoning regarding why the use of aggregate surfaced roofs should continue to be allowed. Dr. Levitan responded that none was presented, but they mentioned that thermal and ultraviolet (UV) protection are a benefit of aggregate surfaced roofs.*

*Dr. Harris mentioned that this is the type of information that should be included in the cost-benefit analysis done for recommendations. During Dr. Harris' time at NIST, roofing design and materials was a large focus of study. He advised NIST to either retain or seek out roofing design and material expertise in order to address this recommendation. Dr. Phan also mentioned the roofing industry has a ban for buildings (with aggregate on the roof) higher than 33.5 m in tornado alley. However, buildings are built just below the 33.5 m mark.*

*Mr. Holmes asked who makes this ban and wanted to know if it was a decision made at the state level. Dr. Phan responded that for Joplin, Missouri, the ban was made at the state level, and he suspected that other surrounding states have a similar ban.*

*Dr. Sutton asked how the tornado maps can be integrated into the alerts and warning communication work being done and if NIST has thought about making this information accessible to the emergency risk communicators? Dr. Levitan responded that NIST is starting this effort but warned that many people feel that tornadoes are too rare and random to invest much time and effort. Also, the databases that are being used to inform the tornado maps are missing over half of all tornadoes that have occurred in the last 20 years, and the ones in the database may not have an accurate EF rating. Therefore, NIST has focused their work over the past four years on understanding the biases that currently exist in the tornado databases and begin to correct for them.*

*Dr. Harris asked what the point strike probability is on annual basis inside the heart of tornado alley. Dr. Levitan responded that in some cases, it may go down to between 10,000 and 5,000 years.*



*Dr. DesRoches asked if NIST has household data in terms of the number of houses damaged and the costs for the Joplin tornado.*

*Dr. Levitan responded that for Joplin, about 7,500 houses were destroyed, and that NIST has information (i.e. year built, square footage, etc.) on roughly 2,200 houses based on building features that can be identified from an aerial camera. Dr. Levitan expressed that NIST does not have economic information on those homes. He added that NIST can now estimate wind speed and direction based on the data that has been collected and modeled to develop an independent estimate of the tornado timeline of events that occurred during the Joplin Tornado.*

*Mr. Klein stated that given the complexity of understanding wind damage, NIST should try to simply look at buildings that had encounters with tornadoes and sustained minimal damage and incorporate language into the codes and standards to have buildings built similarly. Dr. Levitan stated that NIST must first determine the scientific basis for proposing changes to codes and standards.*

#### **IV. Hurricane Maria NCST Investigation Updates**

##### **[NCST Investigation Introduction:](#)**

Dr. Erica Kuligowski providing the following background information on Hurricane Maria:

- Tropical Storm Maria formed west of the Lesser Antilles on September 16, 2017
- Maria intensified to Category 5 status in two days, with sustained winds of 175 mph
- Hurricane Maria made landfall in Puerto Rico on September 20 as a strong Category 4 storm
- Hurricane Maria is the most intense hurricane to strike Puerto Rico since the Category 5 Okeechobee Hurricane of 1928
- The storm tracked diagonally across Puerto Rico
- Storm surge was also a hazard produced by the hurricane
- There were many hundreds of landslides produced as a result of the hurricane

The NIST Director established a Team under the National Construction Safety Team (NCST) Act on February 21, 2018, to conduct a technical investigation of the effects of Hurricane Maria on the U.S. territory of Puerto Rico and characterize:

- (1) the wind environment and technical conditions associated with deaths and injuries;
- (2) the performance of representative critical buildings, and designated safe areas in those buildings, including their dependence on lifelines; and
- (3) the performance of emergency communications systems and the public's response to such communications.

Dr. Kuligowski also described other NIST authorities, including the National Windstorm Impact Reduction (NWIRP) Act. NWIRP was established to achieve major measurable reductions in the loss of life and property from windstorms. In the 2015 NWIRP reauthorization, Congress designated NIST as the Lead Agency for NWIRP. Other designated Program agencies are the Federal Emergency Management Agency (FEMA), the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). NIST responsibilities include:

- ensuring that the Program includes the necessary components to promote the implementation of windstorm risk reduction measures;

- supporting the development of performance-based engineering tools and working with appropriate groups to promote the commercial application of such tools;
- coordinating all Federal post-windstorm investigations to the extent practical; 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.

NIST is also conducting a scientific study under the NWIRP authority with the following goals:

- 1) the impacts to and recovery of small- and medium-sized manufacturers (SMMs), with a focus on supply-chain disruption, as well as businesses in retail and service industries;
- 2) the impacts to and recovery of education and healthcare services; and
- 3) the impacts to and recovery of infrastructure systems in Puerto Rico, with a focus on infrastructure that supports the functioning of critical buildings (i.e., hospitals and schools) and emergency communications.

NIST will be sharing information on some non-NCST efforts related to Hurricane Maria to provide some context to the Committee on all of the work being done by NIST in response to Hurricane Maria. NIST will be very clear to indicate which work will fall under the NCST Act. The Committee is only authorized to provide consensus advice on the NCST-related projects.

#### *NCST Investigation Goal 1a: The Wind Environment*

Dr. Joseph Main described the project supporting Goal 1a of the NCST Hurricane Maria Investigation, focused on characterizing the wind environment associated with the hurricane's impact on Puerto Rico. This project will use measurements and modeling of the time-dependent hurricane-wind-field in conjunction with wind-tunnel studies of topographic effects, and will document other hazards (including storm surge, rainfall, flooding, and landslides) associated with the hurricane. This project will also support multiple aspects of the investigation, including:

- attribution of deaths and injuries, the performance of critical buildings and designated safe areas;
- dependence of critical buildings on lifelines; and
- emergency communications systems.

The primary focus of the project will be on the characterization of the wind environment, including topographic effects. Much of Puerto Rico is mountainous, which can result in significant speed-up of winds. NIST plans to develop a time-dependent wind-field model of Hurricane Maria's impact on Puerto Rico that optimally matches available measured data. Two models will be produced: (1) an initial model with topographic effects incorporated using existing data, and (2) a final model with improved modeling of topographic effects, with quantified uncertainty in model results. The wind speed-up effects will be characterized based on the model. Computational fluid dynamics (CFD) will also be used to evaluate topographic effects in regions that are not tested in the wind tunnel model.

Coordination with the following agencies is planned to identify relevant data sources and modeling capabilities to characterize other hazards: storm surge (NOAA), rainfall and flooding (NOAA, NASA, USGS, UCAR), and landslides (USGS and NASA). Both spatial and temporal variability of hazards will be considered. Interaction of hazards can be significant, and the following will also be considered: wind-

driven rain; storm surge and rain-induced flooding; and the effect of prior rainfall from Hurricane Irma on preconditioning the land surface.

Specifications have been developed to award contract support for the identification of wind tunnel testing of topographic effects and the wind-field modeling and probabilistic wind hazard analysis. The anticipated award date for contract support is Fall of 2018, but it may be later. The initial forensic wind field model developed under this project will build upon the parameters of the hurricane model used in ASCE 7-16. Wind maps were adjusted to provide the best fit for Hurricane Maria's observed wind speeds, directions, and atmospheric pressures. This model will benefit from the data gathered from the current wind tunnel testing being conducted by FEMA under the mission assignment agreement NIST has with FEMA.

***Committee Discussion of the Overview of the NCST Hurricane Maria Investigation and Goal 1a, the characterization of the wind environment:***

*Mr. Klein asked if there are multiple sources available that can be used to conduct the wind tunnel testing that this project will require. Dr. Main responded that the University of Florida is already building topographic models that are uniquely suited for this project's needs. Any other facility would need to match their capabilities in order to meet the specifications that have been developed by NIST. A Sources Sought notice was issued through the NIST contracting office to seek capable labs, and only the University of Florida was able to meet the requirements, so a sole source acquisition strategy seems to be valid at this time.*

*Mr. Klein stated that this project will have a high dependence upon CFD, which will need to be validated by wind tunnel data. What will NIST do if the computations are not validated by the wind tunnel data and you encounter discrepancies that cannot be resolved? Dr. Main responded that the physical locations that we most want to test for wind data will be visited in person, and the wind tunnel will be used in order to minimize our reliance on the CFD modeling.*

*As a follow-up, Mr. Klein stated that there seems to be a difference in wind density and wind speed gradient across the width of the island that would be difficult to model in a wind tunnel and asked about how this will be addressed. Dr. Main responded that the wind model testing will only use straight-lined winds, which is consistent with the approach used for building codes. The final wind-field model for the island will have topographic speed-up effects for all directions and will be able to consider these factors and capture their effects.*

*Dr. Harris asked how many anemometer records does NIST have to calibrate the analytical and wind tunnel studies. Dr. Main responded that there is a network in the Caribbean that has between 12-20 weather stations around Puerto Rico and near the Virgin Islands. NIST is also exploring other sources of data for wind speed measurements in addition to the NWS. Dr. Levitan added that many stations that were able to record data only recorded data for a portion of the storm, not the entire storm. NIST will also reach out to facilities such as the Environmental Protection Agency (EPA), the U.S. Coast Guard, and other sources that may not be a part of a large network.*

## NCST Investigation Goal 1b: Characterize the technical conditions associated with deaths and injuries

Dr. Judith Mitrani-Reiser described the objective of this project is to complete a quantitative morbidity and mortality assessment of Puerto Rico and to better understand how damaged buildings and supporting infrastructure played a role in the injuries and deaths associated with Hurricane Maria. The study results will provide guidance to improve codes and standards and inform future approaches to accurately attribute and predict life loss due to windstorm building failure(s).

There have been various messages regarding the death count in Puerto Rico resulting from Hurricane Maria. Up until recently, there were no guidelines in the U.S. for how to attribute deaths to natural disasters due to a lack of standards, inconsistent data collection methods, and reporting. The Centers for Disease Control and Prevention (CDC) released guidelines on how to attribute deaths to disasters in October of 2017, a month after Hurricane Maria made landfall in Puerto Rico. Because of the lack of guidance on mortality attribution in disasters, a specific challenge for this project will be identifying those who died as a result of the event. Death certificates generally greatly underestimate deaths (both direct and indirect) caused by a disaster event. Because the death certificates do not have "Hurricane Maria" listed as the cause of death, then it is very easy to attribute the death to another cause. This is not a problem unique to Hurricane Maria; other hazardous events have encountered similar difficulties resulting in deaths either being over or underestimated. Population surveys may provide a more accurate death count, but they can over-estimate the number of deaths attributable to the event.

Dr. Thomas Kirsch, the Director of the National Center for Disaster Medicine and Public Health (NCDMPH), provided some background information about his organization. The NCDMPH was founded in 2008 under HSPD 21 to be "...an academic center of excellence in disaster medicine and public health...", and that it "...shall lead Federal efforts to develop and propagate core curricula, training, and research related to medicine and public health in disasters." The Presidential Directive founding the NCDMPH established it under multiple departments. The Department of Defense, Department of Homeland Security, Department of Health and Human Services, Department of Transportation, and the Department of Veterans Affairs are all sponsoring agencies for the NCDMPH. The NCDMPH is an Academic and Federal organization.

In order to recommend changes to evacuation and emergency response procedures and for improvements to building standards, codes, and practice, this project will use scientifically rigorous methods for:

- attributing morbidity and mortality to windstorms (directly and indirectly),
- examining the health impact associated with building and building system failures in windstorms,
- developing a process to integrate epidemiology and engineering methodologies and tools that better determine the risk factors of and predict life loss due to failures in the built environment.

NIST will be hosting a meeting on September 6-7, 2018 to discuss the state-of-the-practice in post-disaster field data, collection methods, and sampling methodologies across multiple disciplines, including engineering, sociology, economics, geography, public health, and health experts. This information will be used to assess the availability and quality of injury data, identify optimum methods within each field, and potentially identify interdisciplinary methods for future post-disaster studies. While it may be too late to find the perfect sampling for Puerto Rico, this effort has great potential to improve the ability to study morbidity and mortality for future disasters.

**Committee Discussion of Goal 1b, the technical conditions associated with deaths and injuries:**

*Dr. DesRoches asked how secondary deaths and increased deaths due to stress over time, particularly for elderly people, can be captured under this project. Dr. Kirsch responded that the studies that currently exist on increased stress are purely excess death studies, (increased heart attacks, strokes, etc.). It is known that after a disaster there is an increased rate of stress-related deaths, but they are part of a very broad epidemiological discussion.*

*Dr. DesRoches asked if mass burials occurred in response to Hurricane Maria. Dr. Kirsch responded that this did not happen often because there were few deaths immediately after Hurricane Maria. Also, a body cannot be buried in Puerto Rico without a death certificate.*

*Dr. Corotis stated that most of these deaths will be indirect and asked if the study is mandated to look for building failure deaths. Dr. Mitrani-Reiser responded that we are mandated to try to understand if and how buildings killed people. We must understand how building failures resulted in deaths so that we can develop recommendations for changes to codes and standards to prevent those types of deaths from occurring again. Much of the preliminary data that has been gathered is focused on failures of the healthcare system and the healthcare infrastructure, specifically hospitals and how they failed after the event and if access was an issue. A part of this project will be to survey family members of the deceased to understand how people died. Dr. Kirsch added that this is another reason why this project is unique and important, perhaps 20 people died directly from building failures (i.e., a beam falling on someone). However, it is known from the excess death studies that lack of access to healthcare as a result of the event (i.e., broken hospitals, dialysis centers, and primary care facilities, etc.) led to hundreds and possibly thousands of deaths. Understanding the indirect deaths and how the long-term effects of building failures, specifically hospitals, impacts a population is the critical.*

*Dr. Corotis mentioned that this project could have a death classification challenge as he felt there could be a fine line between the direct and indirect deaths since a beam falling on an individual and the lack of the availability of medical services due to an inoperable hospital could still result in death. Dr. Mitrani-Reiser then further clarified that if the damage to the building resulted in the lack of critical service delivery, then that information needs to be captured in the study. Dr. Kirsch added that this study will explore potential domino effects and the linkages between structural failure and mortality, such as power failure.*

*Mr. Klein asked if there has been any thought of a mortality study being done in Puerto Rico a year or two years after Hurricane Maria to see what can be learned about the death rate after the effects of Hurricane Maria. Dr. Kirsch stated that this has been done in the past and should be done for this event, but depends on funding for such studies. One of the challenges for public health research under disaster science is that there is very little funding available. The George Washington University study came from a combination of Puerto Rico's own funding and funding from FEMA. Looking at a healthcare system-wide failure like what occurred as a result of Hurricane Maria would be incredibly useful for the healthcare community.*

*Dr. James Harris stated that Hurricane Irma passed by a few weeks before Maria and caused significant power outages. He then asked how this project will parse the impacts to infrastructure from Hurricane Irma and Hurricane Maria and does it matter. Dr. Kirsch responded that information regarding the*

*impacts and timing of Hurricane Irma was not captured in other studies conducted and that it could be included in the study conducted under this investigation.*

*Dr. Jeannette Sutton asked what types of codes and standards will this study aim to impact (e.g., will it be measurement standards or policy standards)? She also asked if NIST expected to receive pushback from organizations that are now being attributed for the indirect causes of death? Dr. Mitrani-Reiser stated that this project seeks to understand building performance in general and if any inaccuracies in codes and standards are identified that could result in the loss of life then NIST will seek to make recommendations to improve upon those codes and standards. Dr. Kirsch added that there has been a great deal of discussion in the government lately regarding the regional preparedness of healthcare systems. There is a Hospital Preparedness Program (HPP) under the Office of the Assistant Secretary for Preparedness and Response (ASPR) which is under the U.S. Department of Health and Human Services which has been specifically looking at hospitals and how they need to improve their preparedness and performance in the wake of catastrophic events. Organizations are now looking at the need for hospitals to be prepared for hazardous conditions. These studies can help to inform the educational material used to help hospitals prepare for hazardous conditions. Dr. Mitrani-Reiser added that Captain Noe of the CDC has been advising the Hurricane Maria NCST Investigation; in the weeks after the event the CDC published Vital Statistics Guidelines. This project will look into how the information released by the CDC affected the completion of death certificates after Hurricane Maria and how the deaths were attributed to direct or indirect causes.*

*Dr. Ross Corotis commended the team on their efforts thus far and the direction of the study and commented that the variance in death count from different studies could likely be attributed to the methodology and definitions used by each study. Dr. Mitrani-Reiser added that historically, there has been very little data regarding the connection between building failures and building failure fatalities, and the data available has not been of the highest quality. Dr. Kuligowski also pointed out that this is a cross-cutting project that will be looking at the potential miscommunication and loss of communication impacts on indirect and direct deaths. As a goal of the Hurricane Maria program, NIST would like to understand those failures of communications to determine how they can be improved upon. Mr. Mike Newman reiterated that this investigation is non-fault finding, and that the goal of this project is to help to rectify the approach used to account for the mortality and morbidity in the wake of hazardous events. As with previous NCST investigations, no parties will be identified as being at fault by NIST. Dr. Kirsch stated that under this project, he plans to develop a plan to map excess deaths to specific geographic regions and then use sociology and epidemiology-based techniques to describe the causes of death. This type of approach was not taken with previous studies done in Puerto Rico.*

## **NCST Investigation Goal 2: The performance of representative critical buildings, and designated safe areas in those buildings, including their dependence on lifelines**

Dr. Joseph Main presented on the project focused on the performance of critical buildings, with an objective to characterize the performance of critical buildings in Hurricane Maria, including their dependence on lifelines. There are four components in this effort:

- documenting failures of structural systems, building envelopes, and rooftop equipment, along with the resulting intrusion of wind-driven rain, interior damage, and loss of function for a representative sample of hospitals and schools;
- identifying dependencies in loss of function on lifelines;

- characterizing wind loads on building envelopes and rooftop equipment through wind tunnel testing for a subset of these hospitals and schools to correlate with observed damage; and
- evaluating the adequacy of existing selection criteria and design requirements for storm shelters.

Based on the preliminary reconnaissance done last December and observations from FEMA and other groups, there was limited structural damage for engineered buildings, where the predominant construction is reinforced concrete and concrete-block buildings with concrete roofs. There were some failures of non-concrete roofs and wind-induced damage to and failure of metal building systems, potentially due to corrosion. Even for engineered buildings with good structural performance, however, extensive nonstructural damage and loss of function were observed as a result of water intrusion through compromised building envelopes. The preliminary project plan consists of three areas: (1) documenting performance of critical buildings; (2) forensic wind tunnel testing of selected critical buildings; and (3) evaluation of storm shelter section criteria and design requirements.

The FY 18 five planning tasks presented at the May 16, 2018, NCST Advisory Committee meeting were discussed. NIST will be providing other agencies with information on the performance of schools and hospitals, and plans will be made on the best ways to conduct outreach for more information. Currently, the team is coordinating with FEMA to evaluate the potential need for updates to existing memorandums of understanding, including an information sharing agreement to facilitate the sharing of data.

### [NWIRP Study of Hurricane Maria's Impacts on Puerto Rico: Preliminary Project Plan for Evaluating Infrastructure Support of Critical Buildings](#)

Dr. Ken Harrison from the Community Resilience Group gave a presentation on NWIRP's project on infrastructure support of critical buildings. Other team members working on the project include. The goal of this effort is to make recommendations for increasing resilience through changes to codes, standards, and practices that relate to power, water, and transportation infrastructure. The areas of study for this project include impacts, recovery, and planning. A highly simplified network diagram has been developed showing critical building functional dependencies on infrastructure, including statistics from Hurricane Matthew (2016) and Hurricane Harvey (2017). Networks like these are needed as input for systems models under development within the NIST Community Resilience Group.

NWIRP infrastructure project's preliminary study plan has four main goals:

- 1) Establish partnerships and official collaborations:  
Argonne National Laboratory and the NIST Smart Grid Program are potential collaborators
- 2) Gather information at the community level:  
200 semi-structured interviews with power, water, and transportation officials at local and regional levels and municipal officials and a contract for interview research services has been written and submitted to NIST's acquisition management division.
- 3) Extend and test NIST community resilience planning systems models:  
Equations representing reserve capacity such as diesel generators have been entered into NIST systems modeling framework.
- 4) Apply the established model in a Puerto Rico-based resilience planning case study.

**Committee Discussion on Goal 2, the performance of representative critical buildings, and designated safe areas in those buildings, including their dependence on lifelines:**

*Dr. James Harris asked why the word "forensic" was used in the studies, as this word implies a connection with a crime. Dr. Main agreed and said he will edit the text on his slide to better describe the intent of the study.*

*Dr. Harris stated the power grid is strongly affected by windstorms because it is above ground. That is not the case for the water distribution system, as it is mostly buried. Dr. Harris went on to ask if NIST will be looking at flooding and water distribution under the NWIRP authority, and if so, how does it fall under NWIRP. Dr. Mitrani-Reiser stated that anything that is related to the building or the related to the structure falls under the NCST authority; if it is outside the building then it is to be evaluated under the NWIRP authority.*

*Mr. William Holmes asked if there was any indication, other than the retrofit designs mentioned in the presentation, that the schools were designed to better withstand wind hazards since they are often used as shelters. Dr. Main responded that additional information needs to be collected before we can answer that question. Dr. Levitan followed up by saying that regardless of how the schools were constructed they were used as emergency structures and recovery structures and the rationale behind that was that they were concrete buildings that were supposedly outside of the floodplain, but these claims need to be evaluated further.*

*Mr. Klein asked about the planned wind tunnel studies and the correlation between the studies and damage to buildings; he specifically wanted to know if the wind tunnel studies for specific buildings in Puerto Rico would be a one-to-one correlation or for generic buildings? Dr. Main responded that we have identified specific buildings in varied regions with different wind loads and rooftop configurations to be evaluated. This will allow the team to see and compare the differences in performance, given the varied characteristics of each building.*

**[NCST Investigation Goal 3: The performance of emergency communications systems and the public's response to such communications](#)**

Dr. Erica Kuligowski described the objective for the project on emergency communications, which is focused on the role of emergency communications in public response for those under imminent threat from Hurricane Maria by investigating the use of communications in disaster response during and immediately after the event. The preliminary investigation plan for this project has been updated since the May NCSTAC meeting. Interviews and surveys in selected communities are being planned throughout the Commonwealth. Communities will be chosen based on factors associated with public response during hurricanes. Some communities did not receive evacuation notices. It was determined that the geographic location on the island would influence the pre-hurricane preparedness. Previous flooding and landslides information can shed light on locations needing future evacuation for imminent threats.

Open-ended interviews will be conducted with regional and local emergency managers. The following information will be collected:

- pre-hurricane communication procedures
- situational awareness prior to and during Hurricane Maria



- communication decisions with the public
- types of information disseminated to the public before and after via media
- challenges encountered in communication during and after the event

Structured surveys with sampled households within each of the selected communications will obtain information on pre-hurricane preparedness activities, types of emergency information needed before and after, and challenges encountered in obtaining the information. These include dwelling types and proximity to water and the coast.

Messages will also be collected from multiple sources to help determine how residents were informed, which media was used, whether it was online, social media, NOAA Weather Radio, or television. These message sources will be obtained from National Hurricane Center and National Weather Service Weather Forecast Office in San Juan, Governor of Puerto Rico, State Agency for Emergency Management and Disaster Management (AEMEAD), and broadcast meteorologists.

Next steps include sampling strategies among selected communities, working with the NIST Statistical Engineering Division. A contract is expected to be awarded in late fall for contractors to create survey and interview protocols. Pilot testing will also be performed on the survey instrument. Spanish translation will also be included as one of the contract requirements.

Dr. Marc Levitan described infrastructure-related aspects of the project, including the causes of the loss of functionality and extended duration of outages of wireless communication systems in Puerto Rico following Hurricane Maria. A Federal Communications Commission graph showed the percentage of cell site outages. The island had lost almost complete cell coverage, about 95 percent.

NWIRP's Preliminary Study Plan includes the following:

- collect data on damage caused to cell towers, equipment, cabling, and related components of wireless communications systems
- collect information on codes, standards, and regulations governing design and construction of cell towers and wireless communication equipment
- determine hazard levels experienced at cell site locations from the Hazard Characterization Project
- Evaluate tower and equipment performance with respect to the hazard levels experienced at each site and code design requirements

Progress updates are ongoing concerning the types of information to gather, which includes: daily cell site outage information by county, information on recovery of daily call and text volume, locations of 1,039 registered communication towers as of 2006, and post-Maria aerial imagery of towers.

The team will be contacting government agencies and private-sector entities to get information on damage data and installations, including the FCC and FEMA, in Puerto Rico. This data will contain codes, standards, regulations, and practices governing the wind load design and construction of communications towers and any design requirements for other hazards.

**Committee Discussion on Goal 3, the performance of emergency communications systems and the public's response to such communications:**

*Dr. James Harris asked if cell sites have independent power or if they depend on the power grid. Dr. Marc Levitan replied that a lot of them did have backup power from generators, but there were problems getting diesel to the sites because of theft. There was, obviously, a huge demand for generators. Dr. Kuligowski said she saw persons standing by generators to prevent theft on her recent visit.*

*Dr. Ross Corotis asked if the Hurricane Maria Program would be maintaining survey information identifying the individuals providing the data used for the study. Dr. Erica Kuligowski responded that she is not familiar with any such requirement and does not intend on identifying anyone that is spoken to while collecting data on the event.*

*Dr. Jeannette Sutton asked how NIST would handle the massive amount of data collected for this effort.*

*Dr. Kuligowski said they are working with the NIST Statistical Engineering Division to decipher the data and analyze the influencing factors. Regarding the interview data, NIST is developing protocols for how the data will be deciphered through and maintained. She also mentioned that thanks to some base funding, the Statistical Engineering Division is providing personnel to help assist with this project. Currently, NIST is looking both internally and externally for additional human resources to support this effort.*

*Dr. Ross Corotis asked how will human resources with specific expertise useful to the Hurricane Maria program, but not full-time staff be made available to NIST?*

*Dr. Kuligowski responded that it depends upon the structure put in place to acquire the services and the funding mechanism. For example, when the Hurricane Maria program uses personnel from the Statistical Engineering Division that resource allocates up to a certain amount of their time to the Hurricane Maria project and they are paid from Hurricane Maria funds. Dr. Harary added that the Statistical Engineering Division has some base funding already allocated for working with other offices within NIST.*

*Dr. Jeannette Sutton asked if Dr. Kuligowski could expand upon the social media data collected.*

*Dr. Kuligowski responded that a large amount of social media data was collected already but the project has now run into some issues collecting data from Facebook due to their new security protocols that are preventing NIST from viewing large amounts of data from accounts that could provide valuable insight regarding a timeline of the events that occurred during Hurricane Maria. Dr. Kuligowski asked if the Committee had any ideas on how to develop a better relationship with social media organizations.*

**V. Disaster and Failure Studies Updates**

**[DFS Updates on Enhancing the Readiness of Teams](#)**

Dr. Judith Mitrani-Reiser described the three distinct thrust areas of the NIST Disaster and Failure Studies (DFS) Program:

**Statutory Thrust:**

- Evaluate hazard events against deployment criteria

- Manage identification, vetting, and onboarding of NCSTAC members
- Develop an agenda, manage logistics, and set the frequency for NCSTAC meetings
- Create annual NCST reports to Congress
- Coordinate statutory activities across programs related to disasters
- Conduct field studies under various authorities

**Procedures Thrust:**

- DFS SOP development and maintenance
- Deployment Team membership, training, and credentials
- Field and safety protocols
- Human subjects research protocols
- Manage equipment for disaster metrology and personnel protection
- Data preservation, security, and management plan
- Field tools (Non-Disclosure Agreement's, permissions, survey instruments.)
- MOUs with other agencies, academics, and others
- NIST Disaster Working Group

**Research Thrust:**

- Research program focused on disaster metrology, including structural performance and social sciences
- Coordinate research activities with NIST EL Groups, disaster statutory programs, NIST EL Divisions, and other NIST Labs
- Coordination with the Center of Excellence of Risk-Based Community Resilience Planning on field studies
- NIST's Disaster Resilience Grants Program
- Outreach and dissemination

The research thrust for the DFS program focuses on disaster metrology, including structural performance and social sciences. Coordination of research activities across groups in the Division and other operating units at NIST is key, including coordination with the Center of Excellence of Risk-Based Community Resilience Planning on field studies, headquartered at Colorado State University. DFS is trying to answer important questions at the interface of physical and social systems. Some objectives include: the collection of data related to community impact and recovery, validation of models, testing novel field hardware and software, identification of best practices for setting regional scope, sampling protocols and frequency of data collection and recommending specific improvements on standards, codes, and practices based on field studies. DFS is continuously collaborating with FEMA's Mitigation Assessment Teams.

**Committee Discussion on DFS Updates:**

*Mr. Holmes asked if NIST has access to the National Hazards Engineering Research Institute (NHERI) RAPID facility equipment. Dr. Mitrani-Reiser stated that NIST invited the principal investigator for the RAPID center, Dr. Joe Wartman, to give a talk regarding how NIST could use of their equipment. Since the federal government is low on their priority list for deployments, NIST will explore creating an MOU with NHERI to establish agreed upon protocols for NIST's use of their equipment.*

**Public Comment Period**

There were no public comments.

**Summary Remarks**

Dr. Harary thanked everyone again for attending the meeting and advising NIST. He reiterated NIST's appreciation for the Committee's comments and questions. They were some enlightening comments and questions provided that will be useful going forward, for both the NCST investigation and in other areas.

**NCSTAC Preparation of Annual Report to Congress**

The Committee planned and discussed how the NCSTAC Annual Report to Congress would be written.

**Adjournment**

The meeting was adjourned at 5:00 p.m.