National Institute of Standards and Technology
National Construction Safety Team Act
Annual Report
Fiscal Year (FY) 2018

Summary
This annual report to Congress for Fiscal Year (FY) 2018 is required by the National Construction Safety Team (NCST) Act (Public Law 107-231). The National Institute of Standards and Technology (NIST) undertook a new NCST investigation in FY 2018.

In FY 2018, NIST deployed preliminary reconnaissance teams to California and Puerto Rico, in response to the Tubbs Fire and Hurricane Maria, respectively. Based on the recommendations of the preliminary reconnaissance team and evaluation of the criteria listed in the regulations implementing the NCST Act, specifically in 15 CFR 270.102, on February 21, 2018, the NIST Director established a team to perform a technical investigation of the 2017 Hurricane Maria and its impacts on Puerto Rico. The goals of this investigation are to 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 local lifelines; and (3) the performance of emergency communications systems and the public's response to such communications.

NIST is continuing to implement the recommendations to develop consensus standards and code provisions related to progressive collapse from the Federal Building and Fire Safety Investigation of the World Trade Center Disaster (WTC Investigation)[1] and the Technical Investigation of the May 22, 2011, Tornado in Joplin, Missouri (NCST Joplin Investigation)[2].

Highlights of FY 2018 activities include:

- NIST Director established an NCST with eleven members—ten NIST employees and one team member from the National Center for Disaster Medicine and Public Health (NCDMPH)—to study building performance and emergency response and evacuation during Hurricane Maria;
- NIST and the American Society of Civil Engineers (ASCE) made significant progress on the development of tornado hazards maps, as part of the recommendations from the NCST Joplin investigation;
- NIST made significant progress on guidance of public alerts and warnings, as part of the recommendations from the NCST Joplin investigation;
- NIST and Federal Emergency Management Agency (FEMA) collaborated on the submission of 10 proposals for the ICC 500-2020 Standard for the Design and Construction of Storm Shelters, as part of the recommendations from the NCST Joplin investigation; and
- NIST contributed to revisions of the draft consensus standard for disproportionate collapse mitigation of building structures in response to votes and comments from the first ballot.

[1] Report available at: http://www.nist.gov/customcf/get_pdf.cfm?pub_id=909017
[2] Report available at: http://www.nist.gov/customcf/get_pdf.cfm?pub_id=915628

Additionally, NIST held three meetings[3] of the NCST Advisory Committee (NCSTAC) during FY 2018. Two of the meetings were held via web conference on February 20, 2018, and May 16, 2018, and one was held in person at NIST in Gaithersburg, MD, on August 30, 2018. In these meetings, NIST briefed the NCSTAC on:

- progress of NIST implementation of the NCST Joplin Investigation recommendations;
- disaster and failure events scored using the preliminary reconnaissance screening criteria;
- preliminary deployment activities for Hurricanes Harvey, Irma, and Maria and the 2017 Northern California wildfires;
- the team establishment and goals of the Technical Investigation of the Building Performance and Emergency Response and Evacuation During Hurricane Maria (Puerto Rico) (NCST Hurricane Maria Investigation); and
- progress on the NCST Investigation of Hurricane Maria's Effects on Puerto Rico.

A summary of the discussions at these meetings may be found in the FY 2018 Annual Report of the NCSTAC to Congress.[4]

Introduction

In October 2002, the NCST Act was signed into law by President George W. Bush and authorized the Director of NIST to establish and deploy teams to investigate events leading to failure of a building or buildings that result in substantial loss of life or that pose significant potential for substantial loss of life.

The purpose of these investigations is to improve the safety and structural integrity of buildings in the United States. A team shall:

1. Establish the likely technical cause or causes of building failure;
2. Evaluate the technical aspects of evacuation and emergency response procedures;
3. Recommend as necessary, specific improvements to building standards, codes, and practices based on the findings made pursuant to (1) and (2); and,
4. Recommend any research and other appropriate actions needed to improve the structural safety of buildings, and improve the evacuation and emergency response procedures, based on the findings and recommendations of the investigation.

Under Section 10 of the NCST Act, NIST is to provide an annual report to the House Committee on Science, Space, and Technology and to the Senate Committee on Commerce, Science, and Transportation each year. This report is to include:

1. A summary of the investigations conducted by teams during the prior fiscal year;
2. A summary of recommendations made by the teams in reports issued under Section 8 of the NCST Act during the prior fiscal year and a description of the extent to which those recommendations have been implemented; and

[3] Meeting summaries available at: https://www.nist.gov/topics/disaster-failure-studies/national-construction-safety-team-ncst/advisory-committee-meetings
[4] FY 2018 NCSTAC Report to Congress available at: https://www.nist.gov/sites/default/files/documents/2019/02/04/ncstac_2018_report_to_congress.pdf

3. A description of the actions taken to improve building safety and structural integrity by the NIST during the prior fiscal year in response to reports issued under Section 8 of the NCST Act.

This report summarizes NIST's activities under the NCST Act for FY 2018 as required by Section 10 of the Act.

1. Investigations Conducted Under the NCST Act during FY 2018

On September 20, 2017, Hurricane Maria made landfall in Puerto Rico as a strong Category 4 storm, causing fatalities, injuries, and damage to buildings and infrastructure. NIST sent a preliminary reconnaissance team on December 10-15, 2017 to collect information and data to be used to determine whether further NIST study should be conducted. Based on the recommendations of the preliminary reconnaissance team and evaluation of the criteria listed in the NCST Act and its implementing regulations, the NIST Director established a team under the NCST Act to conduct a technical study of the building performance and emergency response and evacuation during Hurricane Maria. The goals of the NCST Hurricane Maria Investigation are to 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.

The recommendation to establish a team was based on analysis of the event against the criteria found in the NCST Act and its implementing regulations (15 C.F.R. Part 270) for establishing a team under the NCST Act and firsthand observations in Puerto Rico made by the NIST preliminary reconnaissance team. The NCST Act and its implementing regulations (15 CFR 270.102) set forth the criteria the Director must use in determining whether to establish and deploy a team "after an event that caused the failure of a building or buildings that resulted in substantial loss of life or posed significant potential for substantial loss of life." The hurricane that made landfall in Puerto Rico on September 20, 2017, caused the failure of buildings that resulted in substantial loss of life.

The criteria considered and associated analysis of the event against each criterion are set forth below.

Criterion 1:
The event was any of the following:
(i) A major failure of one or more buildings or types of buildings due to an extreme natural event (earthquake, hurricane, tornado, flood, etc.);
(ii) A fire that resulted in a building failure of the building of origin and/or spread beyond the building of origin;
(iii) A major building failure at significantly less than its design basis, during construction, or while in active use; or
(iv) An act of terrorism or other event resulting in a Presidential declaration of disaster and activation of the National Response Plan.

Analysis: The September 20, 2017, storm event in Puerto Rico falls within category (i). The hurricane resulted in the failures of many buildings, including metal buildings, and building envelopes and nonstructural systems in engineered buildings that house essential services. The

failures of these buildings resulted in at least 64 deaths, a substantial loss of life.

Criterion 2:
A fact-finding investigation of the building performance and emergency response and evacuation procedures will likely result in significant and new knowledge or building code revision recommendations needed to reduce or mitigate public risk and economic losses from future building failures.

Analysis: The hurricane produced rare near-design wind loads for engineered buildings and other structures across a large geographical area with a heterogeneous building stock. The event provides a unique opportunity to assess the effectiveness of performance objectives set forth by current design standards for critical and other building types and test emergency communications standards and practice in an environment that experienced widespread and long-lasting infrastructure failures. We, therefore, expect that an investigation of the building performance during and after the storm and of the challenges in emergency response and evacuation procedures will likely result in novel insights that will lead to important recommendations for codes, standards, and practices.

In performing the analyses set forth above, the following factors listed in 15 CFR 270.102(b) were also considered:

(a) Whether sufficient financial and personnel resources are available to conduct an investigation — The estimated costs of the recommended investigation were within NIST's fiscal year (FY) 2018 budget and NIST's requested FY 2019 budget. The NCST Act requires that the team be comprised of NIST employees and at least one individual from outside. NIST had sufficient funding within its FY 2018 budget and its FY 2019 requested budget to support the non-NIST team member if required. NIST determined that the employees expected to be drawn from multiple divisions within NIST Engineering Laboratory (EL) were sufficient and available to conduct the investigation.

(b) Whether an investigation of the building failure warrants the advanced capabilities and experiences of a team — The investigation of the building failures caused by Hurricane Maria warrants the advanced capabilities and experiences of the members of the team to determine the characteristics of the storm hazards; the pattern, location, and cause of injuries and fatalities, and how they were affected by the emergency communications and public response; and the performance of representative critical buildings, and designated safe areas in those buildings, including their dependence on lifelines. In the establishment of the NCST, the NIST Director appointed a team with the broad combined expertise (in structural engineering, social science, complex dynamical systems, and risk modeling of NIST team members, and in epidemiology and hazard modeling of non-NIST team members) required to accomplish the investigation objectives.

(c) If the technical cause of the failure is readily apparent, whether an investigation is likely to result in relevant knowledge other than reaffirmation of the technical cause — although some causes of building failures are readily apparent, the investigation is likely to result in knowledge with potential for new recommendations for changes

to codes, standards, and practices. Use of current national standards, codes, and practices may not result in "immediate occupancy" and continued functionality of critical buildings (e.g., hospitals, shelters, and emergency response facilities) and other structures. The term "immediate occupancy", or IO, implies that a building is immediately safe to occupy after a hazard event.[5]

(d) Whether deployment of a team will substantially duplicate local or state resources equal in investigatory and analytical capability and quality to a team — There were no known local or State resources equal to NIST in investigatory and analytical capability nor current or planned investigations addressing the specific scope of the recommended NIST investigation of the Hurricane Maria event.

(e) Recommendations resulting from a preliminary reconnaissance of the site of the building failure — Based on the assessment of the preliminary reconnaissance team of the sites of building failures, the Director of the Engineering Laboratory recommended to the NIST Director the additional study of the event to determine: (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.

The NIST Director, therefore, appointed the following individuals to the NCST for conducting a technical investigation of the effects of Hurricane Maria:

Dr. Erica Kuligowski, Lead Technical Investigator
Affiliation: Research Social Scientist, Wildland-Urban Interface Fire Group, EL, NIST
Relevant Areas of Expertise: human behavior in emergencies, including preparedness, response and recovery behaviors, emergency communications, community resilience, behavioral modeling, and the modeling of social systems.

Dr. Joseph Main, Associate Lead Technical Investigator
Affiliation: Research Structural Engineer, Structures Group, EL, NIST
Relevant Areas of Expertise: wind loads on structures, and computational assessment of structural performance under extreme loads, including modeling the response of structural systems beyond local failure to global collapse.

Mr. Benjamin Davis, Team Member
Affiliation: Management and Program Analyst, Disaster and Failure Studies Program, EL, NIST
Relevant Areas of Expertise: project management and contract support.

Dr. Maria Dillard, Team Member
Affiliation: Research Social Scientist, Community Resilience Group, EL, NIST
Relevant Areas of Expertise: community response to hazards and chronic stressors,

[5] https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1224.pdf

methods for measurement and modeling community resilience, sampling and surveying expertise.

Dr. Jazalyn Dukes, Team Member
Affiliation: Research Structural Engineer, Earthquake Engineering Group, EL, NIST
Relevant Areas of Expertise: earthquake engineering, seismic retrofits of existing buildings and infrastructure, damage assessment and modeling.

Dr. Kenneth Harrison, Team Member
Affiliation: Operations Research Analyst, Community Resilience Group, EL, NIST
Relevant Areas of Expertise: decision-making under uncertainty, infrastructure modeling, interdependencies of distributed infrastructure and building functions, systems analysis.

Dr. Jennifer Helgeson, Team Member
Affiliation: Applied Economics Office, EL, NIST
Relevant Areas of Expertise: resilience to hazards in the built environment, with consideration for cost-effectiveness of community-scale mitigation and adaptation efforts, sampling and surveying expertise.

Dr. Marc Levitan, Team Member
Affiliation: Research Structural Engineer, Structures Group, EL, NIST
Relevant Areas of Expertise: standards for the instrumentation and its deployment to measure wind, structural response to severe wind loading, development of wind standards, model codes, and better building practices.

Dr. Judith Mitrani-Reiser, Team Member
Affiliation: Disaster & Failure Studies Director, EL, NIST
Relevant Areas of Expertise: performance of critical facilities, structured tool development for field reconnaissance, safety and economic impacts of hazards on the built environment, and interaction of humans with the built environment.

Dr. Scott Weaver, Team Member
Affiliation: National Windstorm Impact Reduction Program Director, EL, NIST
Relevant Areas of Expertise: dynamic and diagnostic analyses of North American hydroclimate variability in observationally constrained and climate model datasets, and characterization of extreme climatic events (i.e., droughts and floods).

Dr. Thomas Kirsch, (outside) Team Member
Affiliation: National Center for Disaster Medicine and Public Health (NCDMPH), Uniformed Services University
Relevant Areas of Expertise: board-certified emergency physician, disaster management and science, and qualitative and quantitative epidemiologic methods to improve assessment and disaster management.

The appointed team members will work on four projects related to the investigation:

(1) Hazard Characterization: the objective of this project is to characterize the wind

environment associated with Hurricane Maria's impact on Puerto Rico, including topographic effects, and to document other hazards associated with the hurricane, including storm surge, rainfall, flooding, and landslides in order to understand subsequent building failures.

(2) Performance of Critical Buildings: the objective of this project is to characterize the performance of critical buildings in Hurricane Maria by: (1) 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; (2) identifying dependencies in loss of function on lifelines; (3) 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 (4) evaluating the adequacy of existing selection criteria and design requirements for storm shelters.

(3) Public Response to Emergency Communications: the objective of this project is to investigate the role of emergency communications in public response for those under imminent threat from Hurricane Maria. This project will also investigate the use of communications in disaster response (during and immediately after the hurricane event).

(4) Characterization of Morbidity and Mortality: the objective of this project is to complete a quantitative morbidity and mortality assessment of Puerto Rico, 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, standards and inform future approaches to accurately attribute and predict life loss due to wind storm building failure(s).

Updates on the NCST Hurricane Maria Investigation are updated frequently on the NIST website[6].

2. Summary of Recommendations Made by Teams in Reports Issued Under Section 8 of the NCST Act during FY 2018

During FY 2018, NIST did not issue a report under Section 8 of the NCST Act.

3. Actions Taken to Improve Building Safety and Structural Integrity During FY 2018 in Response to Reports Issued Under Section 8 of the NCST Act

During FY 2018, NIST did not issue a report under Section 8 of the NCST Act.

a. Actions Related to Report on the NIST World Trade Center Investigation:

The following recommendations in the final report of the Collapse of the World Trade Center

[6] NIST Hurricane Maria website: https://www.nist.gov/topics/disaster-failure-studies/hurricane-maria

Towers[1] were addressed in FY 2018 to improve building safety and structural integrity:

- In FY 2012, based on a proposal from NIST, a new American Society of Civil Engineers (ASCE) Structural Engineering Institute (SEI) Standards Committee called the Disproportionate Collapse Mitigation Standard Committee was established. This voluntary standards committee is currently developing a standard, with substantial contributions from four NIST staff who are informing the standard with the results of NIST research. In FY 2018, NIST staff contributed to revisions of the draft standard in response to votes and comments from the first ballot, and a second ballot for the draft standard closed in August of 2018.

b. Actions Related to Report on the NIST Joplin Tornado Investigation:

The following recommendations in the NCST Joplin Tornado Investigation final report[2] were addressed in FY 2018 to improve building safety and structural integrity:

- NIST continued development of tornado hazard maps for use in tornado-resistant design of buildings. This effort directly addresses NIST recommendation #3 (of Recommendations Group 1, *Tornado Hazard Characteristics and Associated Wind Field*) and provides prerequisite technical underpinning for recommendations #5 and #6 (of Recommendations Group 2, *Performance of Buildings, Shelters, Designated Safe Areas, and Lifelines*, in the final report[2]).
- NIST continued to work with the ASCE SEI committee that is developing the new *Tornado Wind Speed Estimation Standard.* The American Meteorological Society (AMS) is also engaged in this effort, and the standard will be a joint ASCE/SEI/AMS document when completed. The committee, co-chaired by National Oceanic and Atmospheric Administration (NOAA) and NIST staff, is developing standardized methods for estimating the wind speeds in tornadoes and other severe wind storms, including significant improvements to the Enhanced Fujita Scale. This standards development activity directly addresses NIST recommendation #4, and supports NIST recommendations #1 and #2 (of Recommendations Group 1, *Tornado Hazard Characteristics and Associated Wind Field*, in the final report[2]).
- NIST is collaborating with the ASCE 7-22 Wind Load Subcommittee's *Task Committee on Performance-Based Design for Wind Hazards,* addressing NIST recommendation #5 (of Recommendations Group 2, *Performance of Buildings, Shelters, Designated Safe Areas, and Lifelines,* in the final report[2]). The Wind Load Subcommittee is creating a performance-based design framework for wind hazards, intended for inclusion in the ASCE 7-22 Standard, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*.
- NIST created and is leading a new Tornado Task Committee within the ASCE 7 Wind Load Subcommittee. This task committee is developing a tornado wind load design methodology and standards provisions, incorporating the NIST tornado hazard maps and results of work on a grant awarded by NIST through the Disaster Resilience Research Grants Program in FY 2017, to study the differences between external and internal wind pressures on buildings in tornadoes versus straight-line winds, that will be proposed for incorporation in a new Tornado Loads chapter for ASCE 7-22. These efforts directly address NIST recommendation #6 (of Recommendations Group 2, *Performance of Buildings, Shelters, Designated Safe Areas, and Lifelines*, in the final report[2]).

- NIST was elected to lead the committee developing the 2020 edition of the ICC 500 *Standard for the Design and Construction of Storm Shelters*. NIST, in collaboration with FEMA, submitted 10 change proposals for this new edition, including changes related to installation of storm shelters in existing buildings. These efforts directly address NIST recommendation #7a (of Recommendations Group 2, *Performance of Buildings, Shelters, Designated Safe Areas, and Lifelines*, in the final report[2]).
- NIST produced Technical Note 1982, *A Review of Public Response to Short Message Alerts under Imminent Threat*. This document presents a review of short message platforms, the usage of these systems for emergencies, and research studies that highlight the response of the public to these alert types. NIST also published a document (Technical Note 2008) that provides evidence-based guidance for communities on the creation and provision of public alerts, including both alerts provided by outdoor siren (warning) systems and "short messages" sent by social media or other short message service (SMS) platforms. This effort supports NIST recommendations #13, #14, and #15 (of Recommendations Group 3, *Pattern, Location, and Cause of Fatalities and Injuries, and Associated Performance of Emergency Communications Systems and Public Response*, in the final report[2]).
- NIST continued working on an annex on community-wide public alerts and warnings in disaster response, including participating in the Second Draft Meeting of the Technical Committee for NFPA 1600 *Standard on Continuity, Emergency, and Crisis Management*. This effort supports NIST recommendations #13, #14, and #15 (of Recommendations Group 3, *Pattern, Location, and Cause of Fatalities and Injuries, and Associated Performance of Emergency Communications Systems and Public Response*, in the final report[2]).

In addition to the actions described above, NOAA's National Severe Storms Laboratory (NSSL) has continued to make significant progress developing a new hazardous weather forecasting platform called Forecasting a Continuum of Environmental Threats (FACETs). FACETs include a grid-based, all-hazard watch/warning paradigm for communicating probabilistic threats. This effort supports NIST recommendation #16 (of Recommendations Group 3, *Pattern, Location, and Cause of Fatalities and Injuries, and Associated Performance of Emergency Communications Systems and Public Response*, in the final report[2]).

4. Preliminary Investigations

NIST uses a screening tool to assess the need for preliminary reconnaissance of disasters and failures that includes the following key decision criteria: event consequences (substantial loss of life or disabling injury, significant potential for loss of life; hazard intensity; consequences to resilience), major challenges in evacuation and/or emergency response, international factors (relevance to the United States), and study impacts (safety of team; new knowledge gains; and potential impact to existing standards, codes, and guidelines). Eleven domestic and international events were scored in FY 2018, including two hurricanes, three wildland-urban interface fires, two building fires, two earthquakes, and two structural failures. Two of the eleven events scored met preliminary deployment criteria in FY 2018 and resulted in the deployment of teams to collect preliminary data and inform recommendations for further study. NIST deployed teams to collect preliminary data in response to two events: (1) Hurricane Maria in Puerto Rico, and (2) Tubbs wildland-urban interface fire in California. Following up on a preliminary deployment of a team in response to Hurricane Harvey in FY 2017, a NIST staff member also participated as a member

of the FEMA Mitigation Assessment Team in FY 2018 to further evaluate the impacts of Hurricane Harvey.

Hurricane Maria made landfall in southeast Puerto Rico near Yabucoa at approximately 10:15 a.m. UTC on September 20, 2017, as a strong Category 4 storm, with maximum sustained winds of 155 mph (155 kt) and a record-breaking minimum pressure of 908 mb[7]. The storm tracked across the center of the island, from southeast to northwest, and with the combined effect of the surge and tide, produced maximum inundation levels of 6 to 9 ft above ground level to the north of Maria's landfall[7]. The hurricane also brought with it more than 20 inches of rain over much of the island, with even higher amounts in some areas, causing hundreds of landslides across Puerto Rico[7]. Hurricane Maria impacted Puerto Rico two weeks after category 5 Hurricane Irma passed to the north of the island. Irma brought tropical storm force winds to the entire island, resulting in extensive loss of power that had only just been restored to most customers a few days before Maria hit. All of Puerto Rico was exposed to hurricane force winds, extreme rainfall, and associated flooding and landslides during Hurricane Maria. Coastal areas around the entire island were also exposed to storm surge. These multiple hazards associated with Hurricane Maria caused severe physical damage to engineered buildings, non-engineered building systems, and infrastructure networks. The storm also caused severe evacuation and sheltering challenges and emergency response challenges.

Hurricane Maria represents a unique opportunity to collect perishable data of damage to buildings and infrastructure, as well as the performance of the emergency management system in the field, in collaboration with federal, academic, and professional partners. NIST sent one preliminary reconnaissance team, totaling four NIST staff, to collect perishable data on the east coast of the island, including the following emergency management zones: San Juan, Arecibo, Caguas, Humacao, Yabucoa, Loiza, Canovonas, Fajardo, and Vieques. The team split their time between collecting building damage data and meeting with local stakeholders. The team focused their efforts on: (1) the performance of residential construction, nonresidential construction, schools, hospitals, and other critical infrastructure subject to peak winds up to 155 mph; (2) how facilities were selected for use as shelters to house people during the storm, and the performance of shelters (many schools were used as shelters) in terms of protecting life safety; (3) the performance of rooftop solar systems attached to structures, (4) the damage to infrastructure systems and the rate at which they recover (an area with little data available); (5) the availability of hazard information and the effectiveness of emergency communications in producing protective actions by citizens and explaining the variance observed; (7) identifying building and infrastructure damage that may lead to functional loss and forcible closures stratified by occupancy type (education, governance, and healthcare); (8) identifying building and infrastructure damage that may lead to business interruption and forcible closures stratified by business; (8) improved hazard characterization and better linkage between the hazard and any observed damages (buildings, trees, signs, etc.); (9) interdependencies between infrastructure and social functions (poorly understood currently) and the relationship between these dependencies and recovery rates; and (10) refining scope and potential study area(s) for a possible subsequent study that aligns with and advances the engineering and science research already underway at NIST. As stated above, the NIST Director determined that this event did meet the criteria for an NCST investigation.

[7] Pasch, R.J., Penny, A.B., and Berg, R., 2019. The National Hurricane Center Tropical Cyclone Report: Hurricane Maria. NOAA/NWS Report AL 152017, 48 pp: https://www.nhc.noaa.gov/data/tcr/AL152017_Maria.pdf.

At least fifteen wildland fires burned in Northern California in October of 2017, impacting multiple counties, including Sonoma, Napa, Mendocino, Lake, Yuba, Nevada, and Butte. The drought conditions for months in California, coupled with low humidity and the Diablo winds (hot, dry winds that typically occur in northern California during the spring and fall) have made these fires a challenge to contain since they began nine days ago. The fires that year were the deadliest in California's history, and resulted in over 40 civilian fatalities, at least 5700 structures damaged or destroyed, approximately 217,000 acres burned, over 75,000 people evacuated, and significant disruption of communication systems and electrical power. A considerable regional area and population was exposed to the fires, causing a large number of deaths, moderate damage to critical lifelines, and severe physical damage to non-engineered buildings. The storm also caused severe evacuation and emergency response challenges. The northern California wildfires represented a unique opportunity to collect perishable data of buildings, infrastructure, and the emergency management system in the field, in collaboration with federal, academic, and professional partners.

NIST sent one preliminary reconnaissance team, composed of five NIST staff, to collect perishable data on the performance of commercial and residential structures within three communities affected by the Tubbs fire in Sonoma County (e.g., Coffey Park, Larkfield, and Fountain Grove). At least half of the total fatalities are attributed to the Tubbs fire (Sonoma County), and so the team concentrated their data collection efforts in locations where fatalities occurred and where vegetation in the wildlands were affected by the Tubbs fires. The team focused their efforts on: (1) physical damage to residential and commercial buildings and the performance of infrastructure systems, including power outages and disrupted communication networks; (2) the availability of hazard information, decisions made by emergency officials, and the effectiveness of emergency communications in producing protective actions by residents/tourists and explaining the variance observed; (3) the performance of evacuation actions and behavior by the public; (4) first responder fire suppression tactics and operations; (5) the efficacy of recent changes to codes, standards and practices; and (6) refining scope and potential study area(s) for a possible subsequent study that aligns with and advances the engineering and science research already underway at NIST. Despite its serious nature, after preliminary investigation, NIST determined that this event did not meet the criteria for an NCST investigation.

The remaining events did not meet the criteria for a preliminary deployment for one or more of the following reasons: no clear study objectives that would impact standards, codes, and practices; unsafe conditions for NIST investigators; no primary authority or in-house expertise of hazard type; construction practice and codes for international events are not similar to those used in the U.S.; no new lessons would be gained; or minimal impact to building occupants.

5. Conclusion

The NCST Act authorizes NIST to establish and deploy teams to investigate building failures that result in a substantial loss of life or pose significant potential for loss of life. In FY 2018, NIST assessed eleven events (fires, earthquakes, hurricanes, and structural failures) using a screening tool that considers: event consequences (substantial loss of life or disabling injury; potential for loss of life; hazard intensity; physical damage) and evacuation and/or emergency response, international factors (relevance to the U.S.), and study impacts (safety of team; new knowledge gains; and potential impact to existing standards, codes, and guidelines). NIST completed two preliminary deployments in FY 2018, and in analyzing the data from Puerto Rico, the NIST Director established a team under the NCST Act to further investigate the

building performance and emergency response and evacuation during Hurricane Maria in Puerto Rico. NIST continues to pursue actions related to improving building safety and structural integrity that were recommended by previous NCST investigations. NIST presented these FY 2018 activities to the NCSTAC during two web-conference meetings on February 20, 2018, and May 16, 2018, and one in-person meeting at the Gaithersburg campus on August 30, 2018.