NIST Hurricane Maria Program Overview

February 26, 2019

NIST-Gov't of Puerto Rico (Dept of Economic Dev. and Commerce) Meeting

National Construction Safety Team members:

Erica Kuligowski, Lead (presenter)
Joseph Main, Associate Lead
Benjamin Davis, Team Member
Maria Dillard, Team Member
Jazalyn Dukes, Team Member
Kenneth Harrison, Team Member
Jennifer Helgeson, Team Member
Marc Levitan, Team Member
Judith Mitrani-Reiser, Team Member
Scott Weaver, Team Member
Thomas Kirsch, outside Team Member (National Center for Disaster Medicine & Public Health)

Hurricane Maria Team in Attendance

- Dr. Erica D. Kuligowski is a research social scientist in the Engineering Laboratory at NIST.
  - Team Lead for the NIST Hurricane Maria Program
  - Leader of a Hurricane Maria project that focuses on investigating the role of emergency communications in public response for those under imminent threat.

- Dr. Joseph A. Main is a research structural engineer in the Engineering Laboratory at NIST.
  - Associate Team Lead for the NIST Hurricane Maria Program
  - Leader of two Hurricane Maria projects, one focused on hazard characterization and another focused on the performance of critical buildings.

- Dr. Judy Mitrani-Reiser is Director of the Disaster and Failure Studies Program in the Engineering Laboratory at NIST.
  - Leader of a Hurricane Maria project to assess the technical conditions associated with deaths and injuries that resulted from Hurricane Maria.

- Dr. Jennifer Helgeson is a research economist in the Engineering Laboratory at NIST.
  - Leader of a Hurricane Maria project examining the impacts to and recovery of small and medium-sized manufacturers and retail and service industries.

Long History of Disaster and Failure Studies at NIST

Earthquakes

San Fernando, CA (1971)

Mexico City, Mexico (1985)

Loma Prieta, CA (1989)

Northridge, CA (1994)

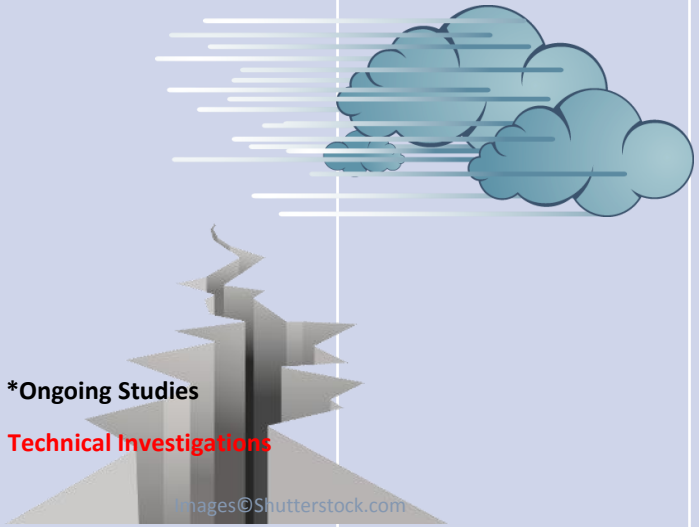
Kobe, Japan (1995)

Kocaeli, Turkey (1999)

Maule, Chile (2010)

Christchurch, NZ (2011)

***Puebla, Mexico (2017)**



***Ongoing Studies**

Technical Investigations

Hurricanes

Camille, MS/LA (1969)

Alicia, Galveston, TX (1983)

Hugo, SC (1989)

Andrew, FL (1992)

Fran, NC (1996)

Mitch and Georges, LAC (1998)

Katrina and Rita (2005)

***Matthew, NC (2016)**

***Harvey, TX (2017)**

***Maria, PR (2017)**

Construction & Building

Skyline Plaza Apartments, Bailey's Crossroads, VA (1973)

Willow Island Cooling Tower, WV (1978)

Kansas City Hyatt Regency, Kansas City, MO (1981)

Riley Road Interchange, East Chicago, IN (1982)

Harbor Cay Condominium, Cocoa Beach, FL (1981)

L'Ambiance Plaza, Hartford, CT (1987)

Ashland Oil Tank Collapse, Floreffe, PA (1988)

U.S. Embassy, Moscow, USSR (1987)

Murrah Federal Building, Oklahoma City, OK (1995)

World Trade Center Disaster, New York, NY (2001)

Dallas Cowboys Indoor Practice Facility, May 2009

Tornadoes

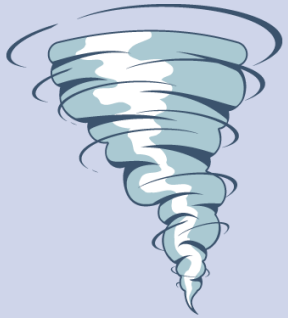
Jarrell, TX (1997)

Spencer, SD (1998)

Oklahoma City, OK (1999)

Joplin, MO (2011)

Moore OK (2013)



Fires

DuPont Plaza Hotel, San Juan, PR (1986)

First Interstate Bank Building, Los Angeles, CA (1988)

Loma Prieta Earthquake, CA (1989)

Hillhaven Nursing Home (1989)

Pulaski Building, Washington, DC (1990)

Happyland Social Club, Bronx, NY (1990)

Oakland Hills, CA (1991)

Watts St, New York City (1994)

Northridge Earthquake, CA (1994)

Kobe, Japan (1995)

Vandalia St, New York City (1998)

Cherry Road, Washington, DC (1999)

Keokuk, IA (1999)

Houston, TX (2000)

Phoenix, AZ (2001)

Cook County Administration Building Fire (2003)

The Station Nightclub, RI (2003)

Charleston, SC, Sofa Super Store Fire (2007)

Witch Creek & Guejito, CA, WUI Fire (2007)

Amarillo, TX, WUI Fire (2011)

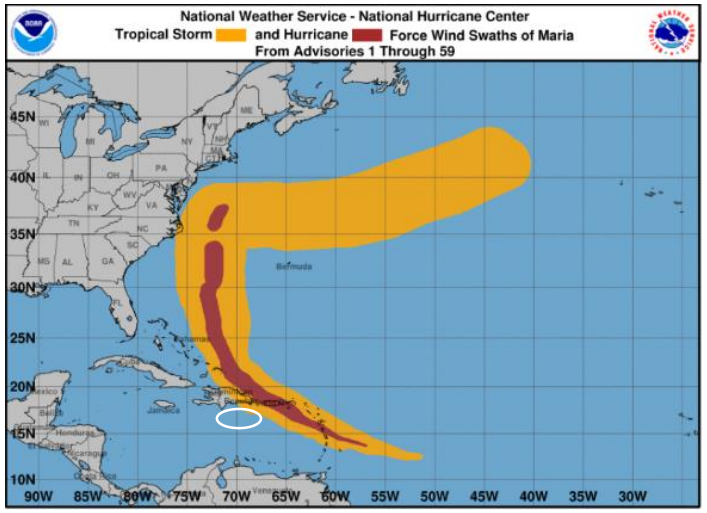
San Francisco, CA (2012)

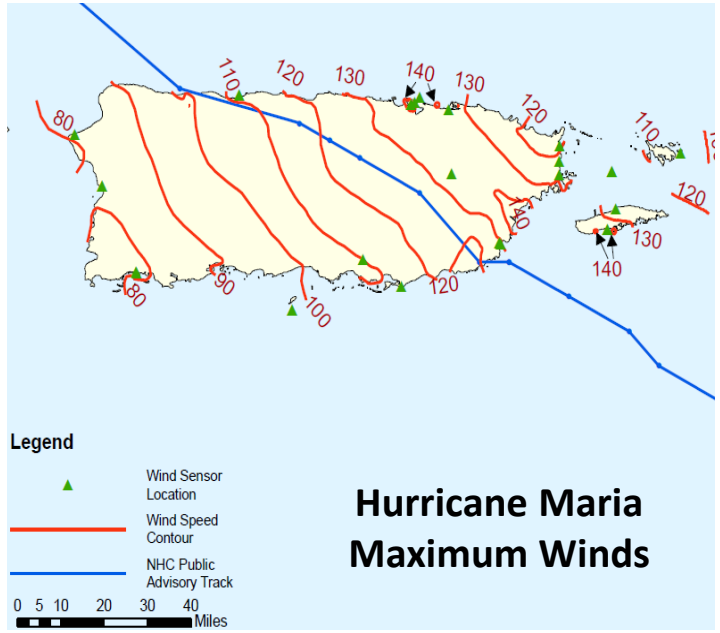
***Gatlinburg, TN WUI (2016)**

***Fuse-47, MD (2017)**

Background: Hurricane Maria's Impact on Puerto Rico

- Hurricane Maria made landfall in Puerto Rico on Sept. 20 as a strong Category 4 storm*.
  - **Winds:** The storm tracked diagonally across PR, with hurricane-force winds extending over the entire Commonwealth; maximum estimated peak wind gusts were 140+ mph (National Hurricane Center (NHC), NIST)
  - **Storm Surge:** Surge produced inundation up to 9 ft along the southeastern coast of PR (NHC)
  - **Rain:** Extensive rainfall, with max 38" (NHC)
  - **Landslides:** Many hundreds of landslides occurred throughout mountainous regions (USGS)
- The entire population of Puerto Rico (~3.3M**) was exposed
- Widely varying estimates of mortality because of many indirect deaths (e.g., lack of access to electricity, clean water, healthcare)





*Source: http://www.weather.gov/sju/maria2017
**Source: https://www.census.gov/quickfacts/PR

Preliminary NIST Reconnaissance of Hurricane Maria (December 2017)

Building Performance:

- Minimal *structural* damage to reinforced-concrete and concrete-block engineered buildings, although some roof failures were observed
- Many buildings with good structural performance still suffered *extensive nonstructural damage and loss of function* due to rainwater penetration of the building envelope
- Severe physical damage and loss of function to metal building systems and non-engineered buildings

Electric Power:

- Complete electrical outage across PR; cascading effects to other lifelines
- Extensive damage to generation, transmission and distribution systems

Communications:

- Near complete loss of digital communications across PR
- Extensive damage to tower- and building-mounted cellular equipment; damage to “hundreds of miles” of fiber optic cable (source: AT&T)

Preliminary NIST Reconnaissance of Hurricane Maria (December 2017)

Emergency Communications and Response:

• Governor urged people in flood/landslide-prone areas to evacuate; Many people/families had to be rescued from flooded areas across the Commonwealth

• Communication challenges between emergency officials, critical facilities, shelters, and with the public for extended periods of time

• Reliance on less efficient communication techniques (e.g., runners) used; redundancy gaps (e.g., few ham radios); overwhelming reliance on media

Education/schools:

- Shelter populations inhabiting schools months after the event, potentially delaying access to education
- Power losses/generator failures also delayed/disrupted education

Healthcare:

- Non-structural building damage/generator failures impacted delivery of healthcare
- Patients in multiple facilities had to be evacuated

Business and Supply Chain:

- Business closure data collected by NIST MEP Center show that food sector had largest impact
- Main reason for closures: power loss, building envelope damage, and road closures

Source: NIST

Goals and Authorities of NCST Investigation

The NIST Director established a Team under the National Construction Safety Team (NCST) Act Public Law 107-231 on February 21, 2018 to conduct a technical investigation of the effects of Hurricane Maria on the U.S. territory of Puerto Rico, with the goals of characterizing:

(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.*

Goals and Authorities of NWIRP Study

Under the National Windstorm Impact Reduction Act Reauthorization of 2015 (Public Law 114-52), NIST is conducting a scientific study of Hurricane Maria's impacts on Puerto Rico and subsequent recovery processes, with the goals of characterizing:

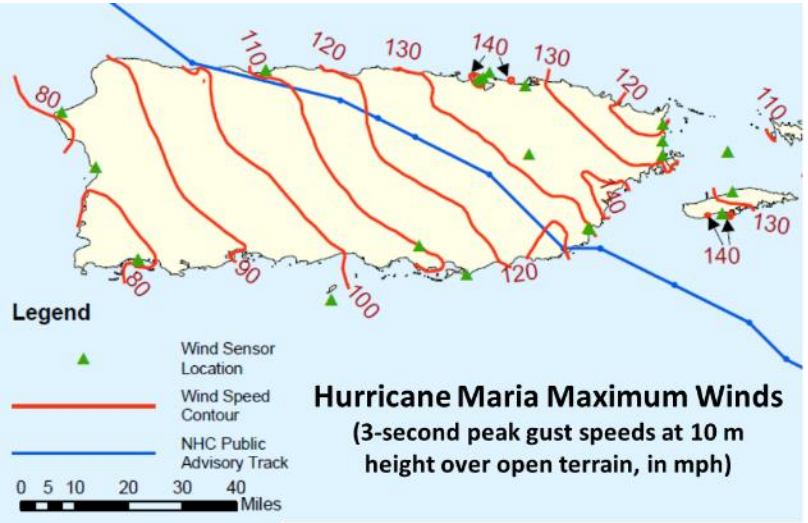
(1) *The impacts to and recovery of small and medium-sized manufacturers (SMMs), as well as businesses in retail and service industries;*

(2) *The impacts to and recovery of education and healthcare services;*

(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.*

Hurricane Maria Project Objectives

- **Hazard Characterization:** 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.



- **Performance of Critical Buildings**: To characterize the performance of critical buildings in Hurricane Maria by evaluating damage and loss of function for representative samples of hospitals, schools, and storm shelters with respect to the hazards they experienced, including an evaluation of selection criteria and design requirements for storm shelters.

Hurricane Maria Project Objectives (cont.)

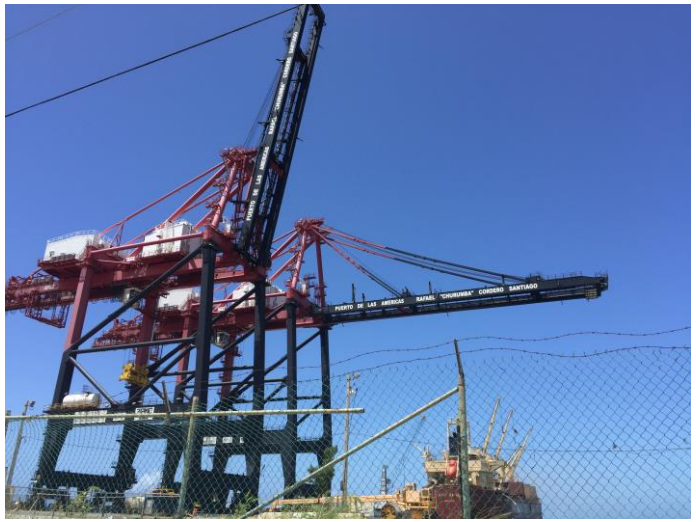
- **Public Response to Emergency Communications**: To investigate the role of emergency communications in public response for those under imminent threat from Hurricane Maria. This project also aims to investigate the use of communications in disaster response (during and immediately after the hurricane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

- **Characterization of Morbidity and Mortality**: To complete a quantitative morbidity and mortality assessment in Puerto Rico, to better understand how damaged buildings and supporting infrastructure played a role in the injuries and deaths associated with Hurricane Maria.

Hurricane Maria Project Objectives (cont.)

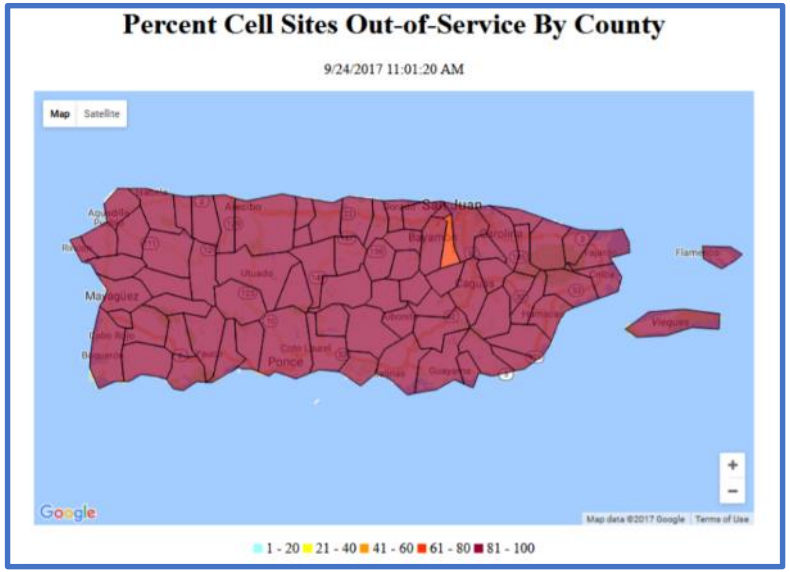
- **Recovery of Business and Supply Chains**: To characterize the recovery of small- and medium-sized businesses, including manufacturing, retail, and service sectors in Puerto Rico to provide greater understanding of business continuity resilience planning and supply chain continuity and how these may differ between industries/affected regions.

- **Recovery of Social Functions**: To examine the recovery trajectories of sampled schools and hospitals in Puerto Rico to identify the underlying characteristics and conditions associated with recovery of critical social functions from Hurricane Maria



Hurricane Maria Project Objectives (cont.)

- **Impacts to and Recovery of Infrastructure Systems Supporting Critical Buildings and Emergency Communications:** To investigate dependencies of building function on infrastructure (power, water, and transportation), including cascading loss of function and sequencing of recovery activities, and to investigate causes of the loss of functionality and extended-duration outage of the wireless communication system in Puerto Rico following Hurricane Maria.

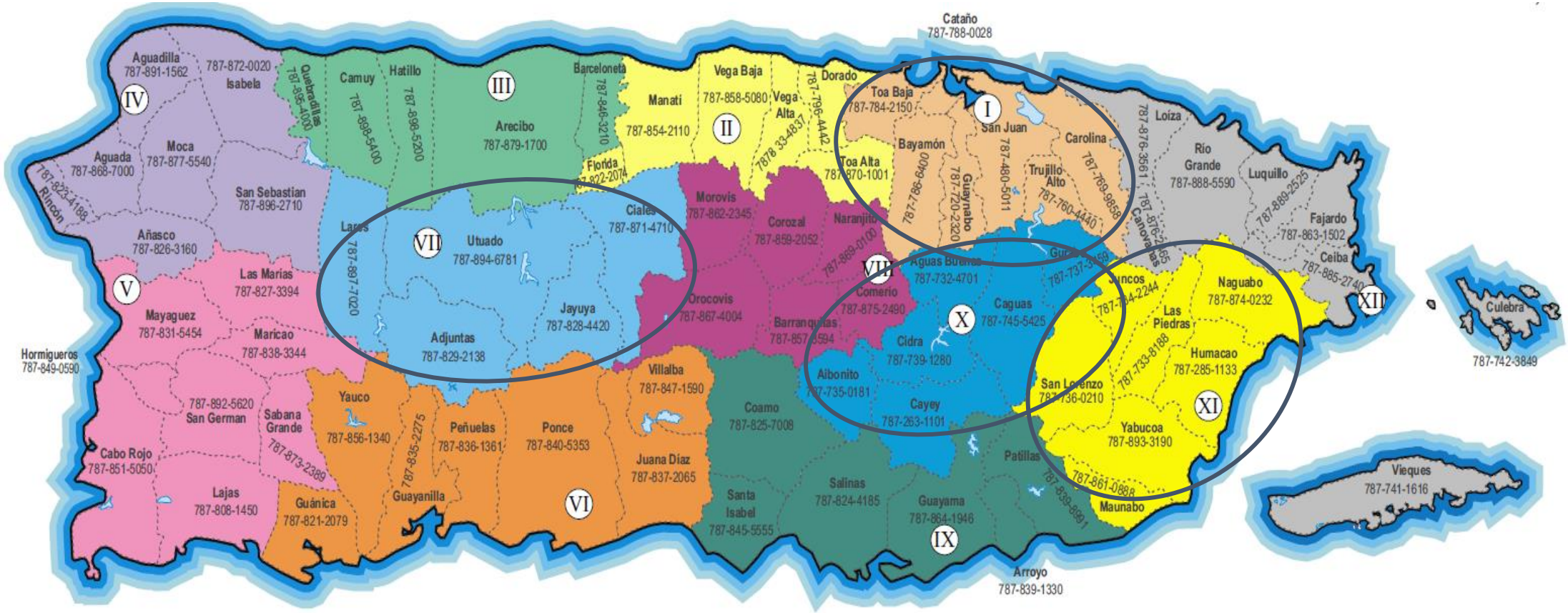


Expected Impacts of the Hurricane Maria Program

Recommendations are anticipated based on the findings:

- Specific improvements to building standards, codes, and practices, as necessary
- Any research or other appropriate actions needed to improve the structural safety of buildings and to improve evacuation and emergency response procedures

Regions Selected for Study



Source: PR.gov
http://prfaa.pr.gov/wp-content/uploads/2017/09/Oficinas-Regionales.pdf

Thank you!

https://www.nist.gov/topics/disaster-failure-studies/hurricane-maria

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