NCST Technical Investigation of Hurricane Maria's Impacts on Puerto Rico (Hurricane Maria NCST Investigation):

Methods

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Hurricane Maria NCST Investigation

Methods

Sept 06, 2019
NCST Advisory
Committee Meeting

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Research Methods Meeting

- The Research Methods Meeting* was organized by NCDMPH (National Center for Disaster Medicine and Public Health) and NIST in support of the Hurricane Maria NCST Investigation, and held on Sept 6-7, 2018.

- The meeting provided NCST members an opportunity to discuss scoping and sampling methods with experts from various fields, including geography, epidemiology, sociology, economics, urban planning, wind engineering, and structural engineering.

- The meeting covered a 1.5-day program composed of presentations by NCST members and a Puerto Rican disaster researcher, a technical panel, and several moderated discussions.

*Federal Register Notice:
https://www.federalregister.gov/documents/2018/09/04/2018-19116/post-disaster-research-methods-meeting

Research Methods Meeting

- A plenary talk was given by Dr. Jennifer Santos-Hernández from the Center for Social Research at U. of Puerto Rico-Río Piedras.
- A methods panel was moderated by Dr. Thomas Kirsch (NCDMPH) and included speakers (Dr. Stachit Balsari from Harvard University, Dr. Joseph Trainor from U. of Delaware, and Dr. David Prevatt from U. of Florida) representing epidemiology, social science, and wind/structural engineering field methods.
- A discussion session on multidisciplinary methods was moderated by Dr. Tricia Wachtendorf from U. of Delaware.

Research Methods Meeting

- Discussions on various scales required for disaster field studies were held for half a day.
- Speakers for population unit of analysis included Dr. Carlos Santos-Burgoa from George Washington U. and Captain Rebecca Noe from CDC.
- Speakers for organizational unit of analysis included Dr. Malgosia Madajewicz from Columbia University and Dr. Vankita Brown from NOAA.
- Speakers for building unit of analysis included and Dr. John van de Lindt from Colorado State U. and Dr. Luis Aponte-Bermúdez from U. of Puerto Rico Mayagüez.
- Speakers for geographical unit of analysis included Dr. Pablo Méndez-Lázaro from U. of Puerto Rico-Medical Sciences Campus and Dr. Kurtis Gurley from U. of Florida.

Mortality Attribution Methods

- The official death toll by the Puerto Rico's Dept. of Public Safety was updated to 2,975 based on George Washington University's study.*
- Excess mortality studies have shown that the deadliest day after Hurricane Maria was September 25, 2017** and the deadliest month was October 2017.*** The highest spikes in number of deaths after the storm was in deaths from sepsis (47% higher in 2017), pneumonia (45% higher in 2017), and emphysema (43% higher in 2017).**
- A population based study estimates a 62% increase in mortality rate between September 20 and December 31 in 2017.**** One third of the deaths surveyed were found to be related to delayed or interrupted health care.****
- A National Academies of Sciences, Engineering, and Medicine Ad Hoc Committee is conducting a review and assessment of the current state of the field and best practices in assessing and quantifying mortality and significant morbidity following large-scale disasters, with a specific focus on disasters declared under the Robert T. Stafford Disaster Relief and Emergency Assistance Act.

* George Washington University , in collaboration with the University of Puerto Rico Graduate School of Puerto Rico, 2018. "Ascertainment of the Estimated Excess Mortality from Hurricane Maria in Puerto Rico," a Project Report for the Governor of Puerto Rico, August 28, 2018.
**Robles, F., Davis, K., Fink, S, Almukhtar, S., 2017. "Official Toll in Puerto Rico: 64. Actual Deaths May Be 1,052." *The New York Times*. December 9, 2017.
*** Santos-Lozada AR, Howard JT. Use of Death Counts from Vital Statistics to Calculate Excess Deaths in Puerto Rico Following Hurricane Maria. JAMA; Aug. 2, 2018: doi:10.1001/jama.2018.10929.
**** Kishore N, Marques D, et al. *Mortality in Puerto Rico after Hurricane Maria*. NEJM 2018; 379:162-170

Mortality Attribution Methods

Many suggestions provided at the Research Methods Meeting for mortality attribution post disasters:

- social autopsies are helpful in providing context for conditions (e.g., social, behavioral, and health systems) contributing to deaths;
- verbal autopsies required to collected primary data and supplement vast amounts of secondary data;
- clinical panels may be used to make final determinations on cause of deaths and identify injury mechanisms related to building failures;
- be mindful of potential biases (i.e., household selection and recall); triangulation of data is critical;
- funeral benefits (from Red Cross and FEMA) may be a useful source of data; and
- review verbal autopsy instrument available from the World Health Organization.

Hurricane Maria NCST Investigation

Evacuation and Emergency Communications Project

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Lead Technical Investigator, NCST Investigation of Hurricane Maria
Team Lead, NWIRP Research Study of Hurricane Maria
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Project Objectives

To support communities' use of emergency communications to alert and warn the public for evacuation and provide vital information during response and recovery

1. Identify the factors that influenced the public's decision to take protection (evacuate) prior to the hurricane, and to understand the role of emergency communications in that decision
2. Characterize the use of emergency communication (technology and information) before, during and after the hurricane

Project Investigation Plan (1/5)

- Structured surveys and follow-up open-ended interviews with the public to identify the factors that influenced the public's decision to take protection (evacuate) prior to the hurricane
- The following information will be collected using a household survey:
  - Pre-Hurricane Maria preparedness activities, previous experiences
  - Types of emergency information sought/received before/during the hurricane
  - Perceptions of this emergency information and other environmental/social cues, including credible source(s)
  - Threat and risk perceptions at the time of protective action decision
  - Protective action decision, actions, timing, and destination
  - Information needs during/after the event
  - Challenges encountered in obtaining information during and for days after the event
  - Demographics
- The following information may be collected using interviews (as examples):
  - Perceptions of risk associated with hurricane and/or flooding/landslide hazards
  - Perceptions of emergency information (incl. NWS products) received prior to the hurricane
  - Experiences in obtaining information during and for days after the event
  - Influence of experiences with Hurricane Irma on response in Hurricane Maria

Project Investigation Plan (2/5)

- Open-ended interviews conducted with regional and local emergency managers, National Weather Service (NWS) officials, broadcast meteorologists, and others responsible for communication with the public from the selected communities to characterize the use of emergency communications before, during and after the hurricane

- Information will be collected on the following:
  - Pre-Hurricane Maria communication procedures/plans, preparedness activities, and previous experiences with hurricanes
  - Situational awareness prior/during Hurricane Maria (including obtaining, interpreting and using National Hurricane Center (NHC)/NWS information or decision-support tools)
  - Decisions made about communicating with the public
  - Types of warning-related information provided to the public before/during the hurricane via multiple channels (e.g., social media, television/radio, Internet, etc.)
  - Sheltering and/or evacuation processes before/during the storm
  - Challenges encountered in communicating with other officials and the public during and days after the event
  - New procedures, guidelines or policy changes since the 2017 hurricanes

Project Investigation Plan (3/5)

- Analysis of emergency/warning messages sent before Hurricane Maria made landfall to characterize the use of emergency communications before the hurricane
- Qualitative content analysis stages:
  - Stage 1: Conceptualization and purpose:
    - ✓ Identify the purpose - Characterizing emergency communications before Hurricane Maria made landfall
    - ✓ Review theory and research - Identify theory-driven metrics of emergency communication effectiveness
    - ✓ Pose specific research questions - To what extent did the messages created and shared by emergency communication stakeholders in Puerto Rico conform to the five content categories and four style aspects recommended by leading government and industry experts?[1]

[1]*Reference: Mileti, D. S., & Sorensen, J. H. (1990). Communication of emergency public warnings: A social science perspective and state of the art assessment. Oak Ridge, TN: Oak Ridge National Laboratory, U.S. Department of Energy.* ***NOTE****: Mileti recently identified 8 essential topics for an alert or warning template, which are incorporated within our 5 main content categories, for more information:* PREPTalks. "Discussion Guide, Modernizing Public Warning Messaging." Federal Emergency Management Agency, https://www.fema.gov/preptalks/mileti. Accessed May 2019.

Guiding Principles for Qualitative Content Analysis

Message Content	Message Style*			
	Specificity	**Consistency**	**Certainty**	**Urgency/Strength**
Sources	Referencing the source of information concerning hazard updates.	Incorporating the same sources and references across channels and time.	Employing word choice that illustrates conviction and assurance.	Including word choice that conveys a sense of urgency.
Guidance (incl. why)	Conveying protective action recommendations (PARs), including how the action reduces consequences with detailed information.	Ensuring that the prescribed PARs included in messages shared over different platforms, times, and sources are similar.	Incorporating word choice that illustrates conviction and assurance when providing PARs.	Choosing words that underscore a sense of urgency when providing PARs.
Time**	Including specific time frames for when the hazard will take place, when ordinances would take effect and when people should follow the prescribed recommendations.	Ensuring that the temporal details included in messages are consistent across channels, source, and time.	Incorporating word choice that illustrates conviction and assurance when describing when the hazard will take place, when ordinances will take effect, and when people should follow the prescribed recommendations.	Describing with a sense of urgency when the hazard will take effect, when certain ordinances would take effect, and when people need to follow the prescribed recommendations.
Location	Being specific when describing which areas will be affected by the hazard, which areas are vulnerable, and where people need to be.	Making sure that the area references across platforms, source, and time are similar.	Using word choice that illustrates conviction and assurance when describing hazard and risk locations.	Alluding to potential risk areas with language that conveys urgency/strength.
Hazard and Impact	Describing the severity of the risks that the hazard poses, including impact, using detailed information.	Incorporating the same hazard descriptions, including impact, across channels, source, and time.	Conveying the severity of the risks that the hazard poses, including impact, with conviction and assurance.	Including word choice that points to a sense of strength and/or urgency when describing the hazard/impact.

**Stylistic features of accuracy and clarity are not explicitly included in this analysis plan; **Includes expiration time, where applicable*

Project Investigation Plan (4/5)

- Qualitative content analysis stages, continued:
  - Stage 2: Study design:
    - ✓ Define and collect relevant content (press releases, printed news articles, multimodal social media content, & WEAs)
    - ○ Develop and validate formal codebook design
    - ○ Operationalize (coding protocol)
    - Specify messages and sampling plans
    - Pretest and establish reliability/agreement procedures

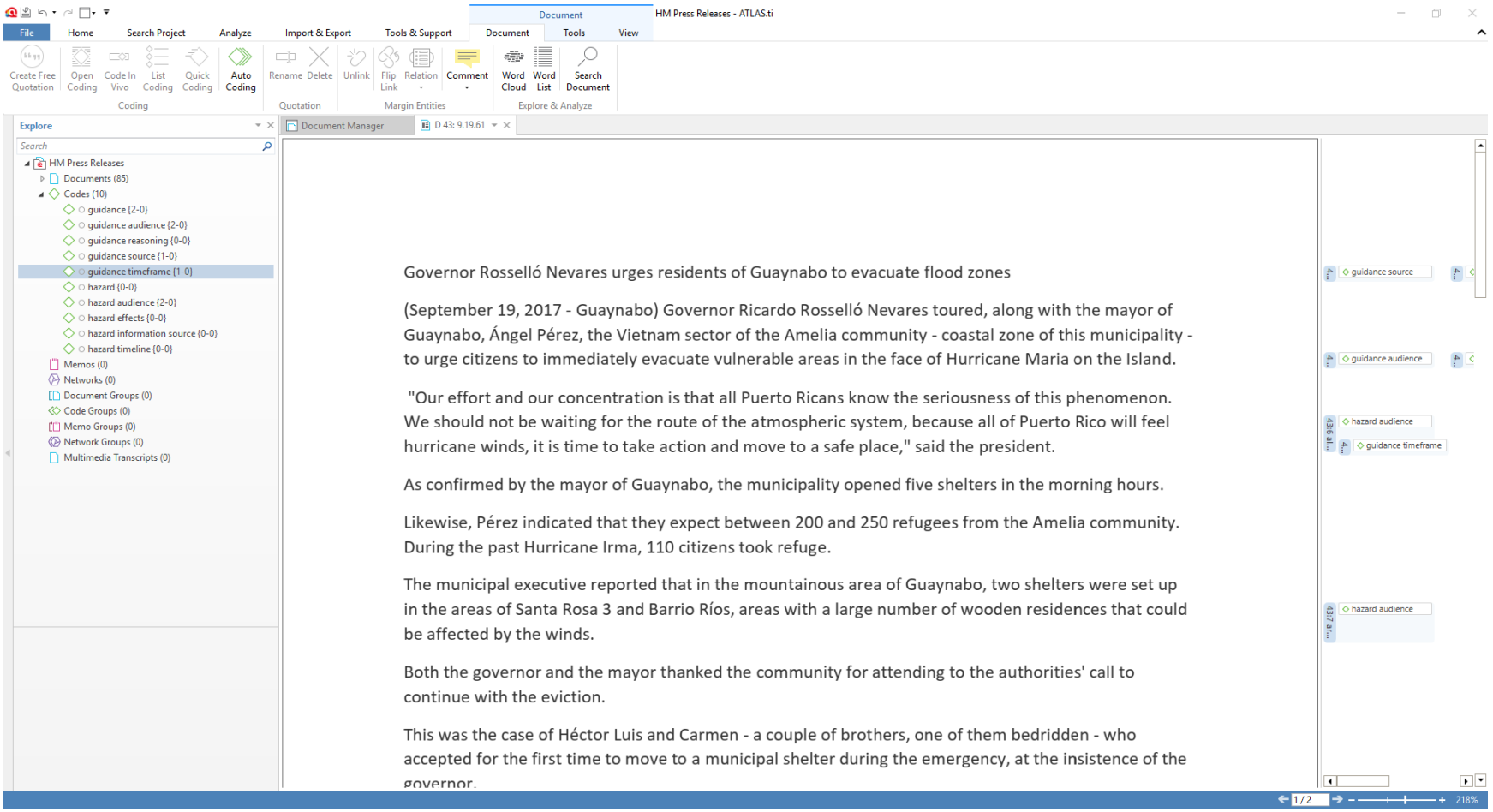
    Current Stage: Iterative Coding Scheme Development Process
  - Stage 3: Analysis[1,2]
    - Classifying and organizing data into themes, concepts, and categories
      - Data indexing by source, channel, time and within these, index the thematic content features (i.e., categories and classifications), guided by effective warning messaging principles
      - Constructing a centralized chart (or other type of data display) and detecting patterns in the data
      - Drawing conclusions and verifying
    - Interpret results based on previous work and theory
    - Report results

[1] Ritchie, Jane, Liz Spencer, and William O'Connor. 2003. "Carrying out Qualitative Analysis." Pp. 219-262 in *Qualitative Research Practice, A Guide for Social Science Students and Researchers*, editedby J. Ritchie and J. Lewis. Thousand Oaks, CA: Sage.
[2] Miles, M.B. and A.M. Huberman. 1994. *Qualitative Data Analysis: An expanded sourcebook,* Sage, Thousand Oaks: CA.

Project Investigation Plan (5/5)

- The emergency communication/messages collected so far:
  - NHC discussion and advisories disseminated during Hurricanes Irma and Maria.
  - NOAA Weather Radio products disseminated during Hurricanes Irma and Maria.
  - Press releases disseminated by the head of government during Hurricanes Irma and Maria.
  - Press conferences held by the head of government and broadcast during Hurricanes Irma and Maria.
  - Social media content (messages and videos) created and shared by key stakeholders during Hurricanes Irma and Maria.
  - Hurricane-related print news articles published in the newspaper with the widest circulation in Puerto Rico in the four days leading up to the storm.
  - All Wireless Emergency Alerts (WEAs) sent during Hurricanes Irma and Maria through the Integrated Public Alert and Warning System (IPAWS).

Screenshot of Coding Scheme using Atlas.ti Software



Muhr, Thomas. (2019). ATLAS.ti [Computer software]. Berlin: ATLAS.ti Scientific Software Development GmbH.

Hurricane Maria NCST Investigation

Performance of Critical Buildings Project

Project Leaders: Joseph Main and Marc Levitan

Objective: 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.

Project Background

- Preliminary reconnaissance after Hurricane Maria showed limited ***structural*** damage to engineered buildings in Puerto Rico:
  - mostly reinforced concrete and concrete block buildings
  - some failures of non-concrete roofs observed
- Even for engineered buildings with good structural performance, extensive ***nonstructural damage*** and ***loss of function*** were observed due to:
  - failures of rooftop equipment
  - damage to roof coverings, rainfall ponding on roofs
  - damage to windows and doors
  - intrusion of wind-driven rain, even through undamaged cladding
  - failure of infrastructure systems, including power and water

Project Plan

- Identify available data on characteristics and performance of hospitals and schools/shelters in Hurricane Maria in coordination with Puerto Rico government agencies and federal partners
- Collect relevant data on the hurricane shelter program in Puerto Rico, including shelter selection criteria and process, and storm facilities used during Hurricane Maria
- Select representative samples of hospitals and schools/shelters for evaluation, considering characteristics of the buildings, the hazards, and other factors
- Perform evaluations of the selected sample of critical buildings:
  - Phase 1: initial document collection and review
  - Phase 2: field investigation, interviews, and additional document collection
- Select a subset of the critical buildings for wind-tunnel testing
  - building models will be extensively instrumented to measure wind loads
  - surrounding buildings and terrain will be included in area models
  - topographic effects on the incoming flow profile will be considered
- Evaluate the performance of critical buildings with consideration of:
  - wind loads and other hazard levels encountered during Hurricane Maria
  - code and standard requirements, including consideration of seismic hazards

Variables of Interest for Building Sample Selection

Independent Variables

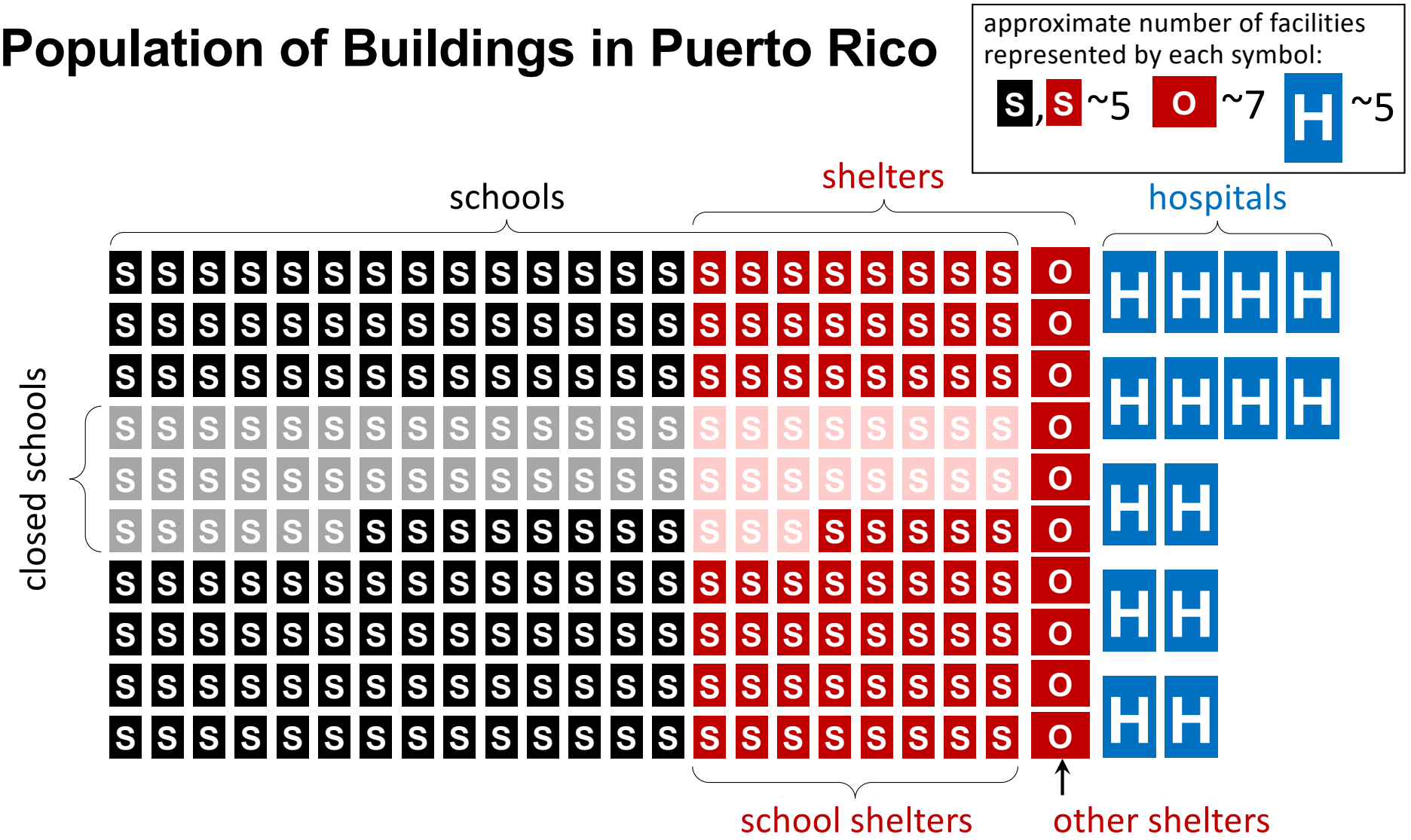
- Geographic location
- Hazard characteristics at building site
- Construction date (applicable building code)
- Structural characteristics
  - Building height
  - Structural system
- Building envelope
  - Window type, window protection
  - Roof system
  - Rooftop equipment
- Surrounding buildings
- Storm shelter designation
- Maintenance and mitigation actions

Dependent Variables

- Building damage and failures
  - Structural system
  - Building envelope
  - Rooftop equipment
  - Interior contents
  - Infrastructure connections
- Fatalities or injuries to occupants during Hurricane Maria
- Loss of function, along with contributing factors:
  - Building damage and failures
  - Loss of electricity or water supply

Sampling Unit: Individual building or group of connected buildings

Population of Buildings in Puerto Rico



Population of Buildings in Puerto Rico

approximate number of facilities represented by each symbol:

S, S ~5 O ~7 H ~5

Buildings in selected Emergency Management Zones:

Population of Buildings in Puerto Rico

approximate number of facilities represented by each symbol:

S, S ~5 O ~7 H ~5

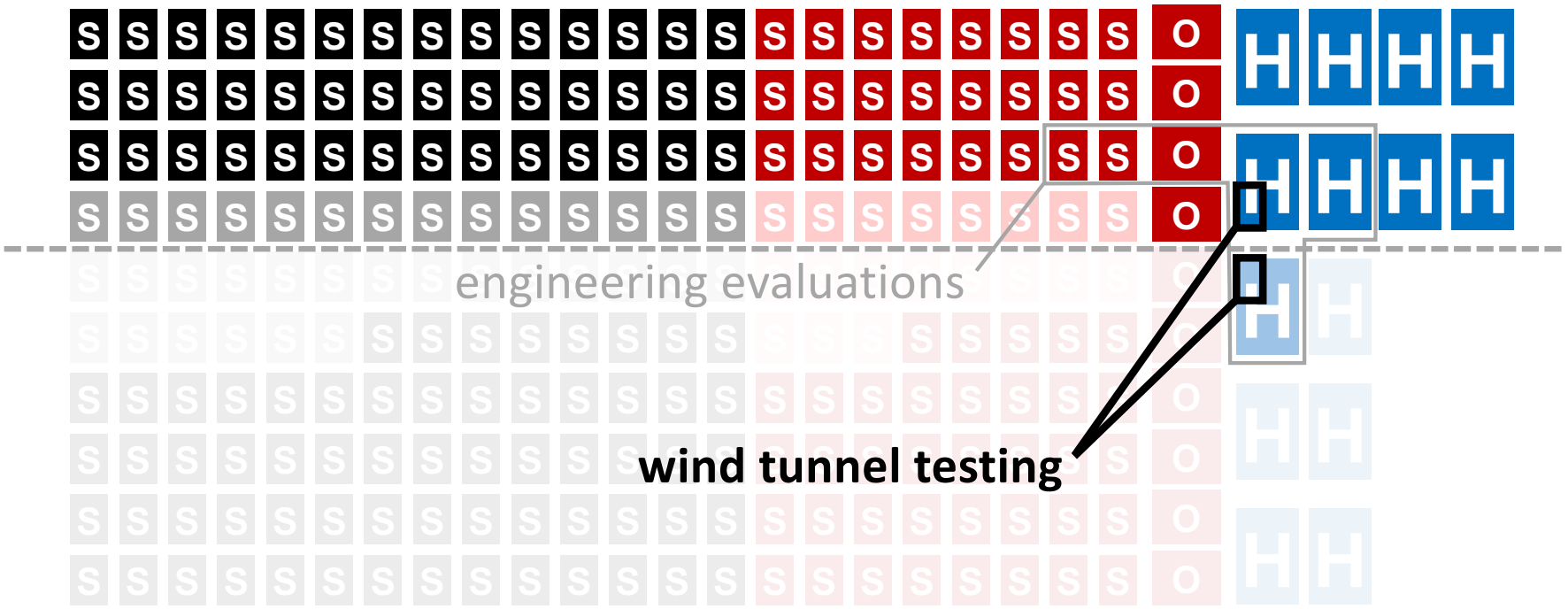
Sample selection for engineering evaluations:

Population of Buildings in Puerto Rico

approximate number of facilities represented by each symbol:

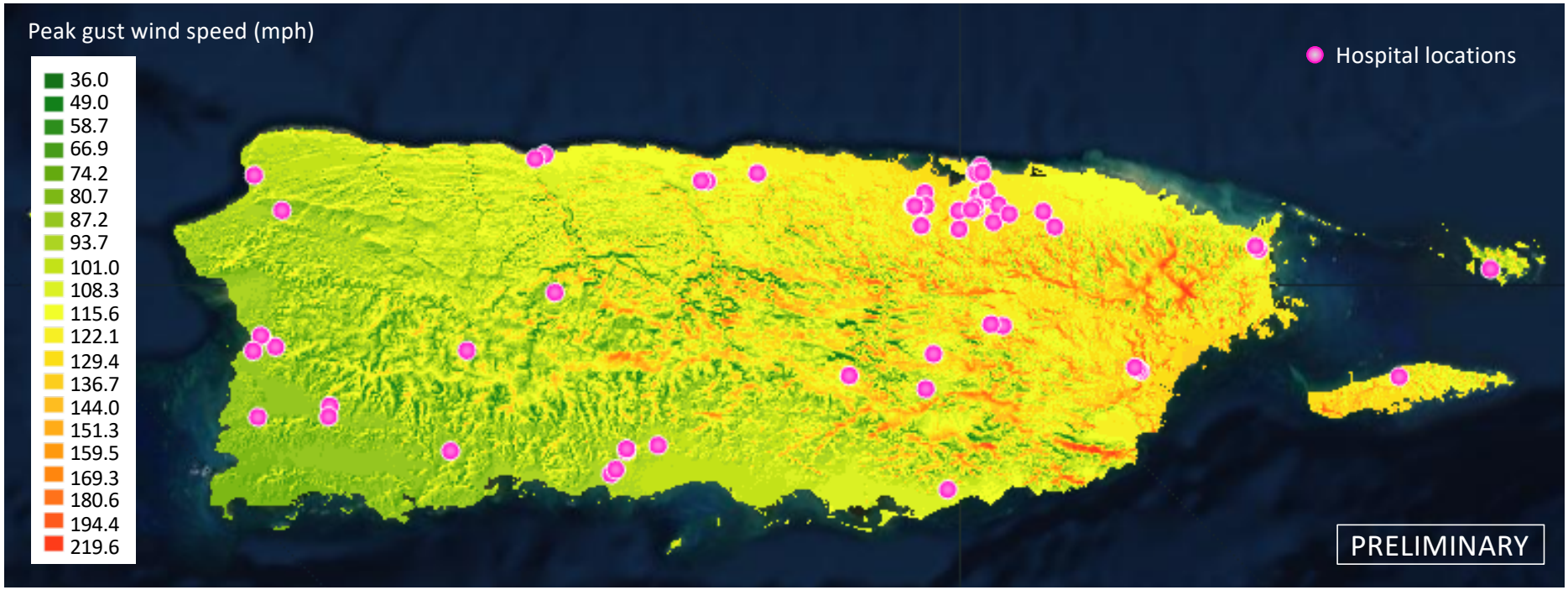
S, S ~5 O ~7 H ~5

Sample selection for wind tunnel testing:



Wind Hazard Characteristics at Hospital Sites

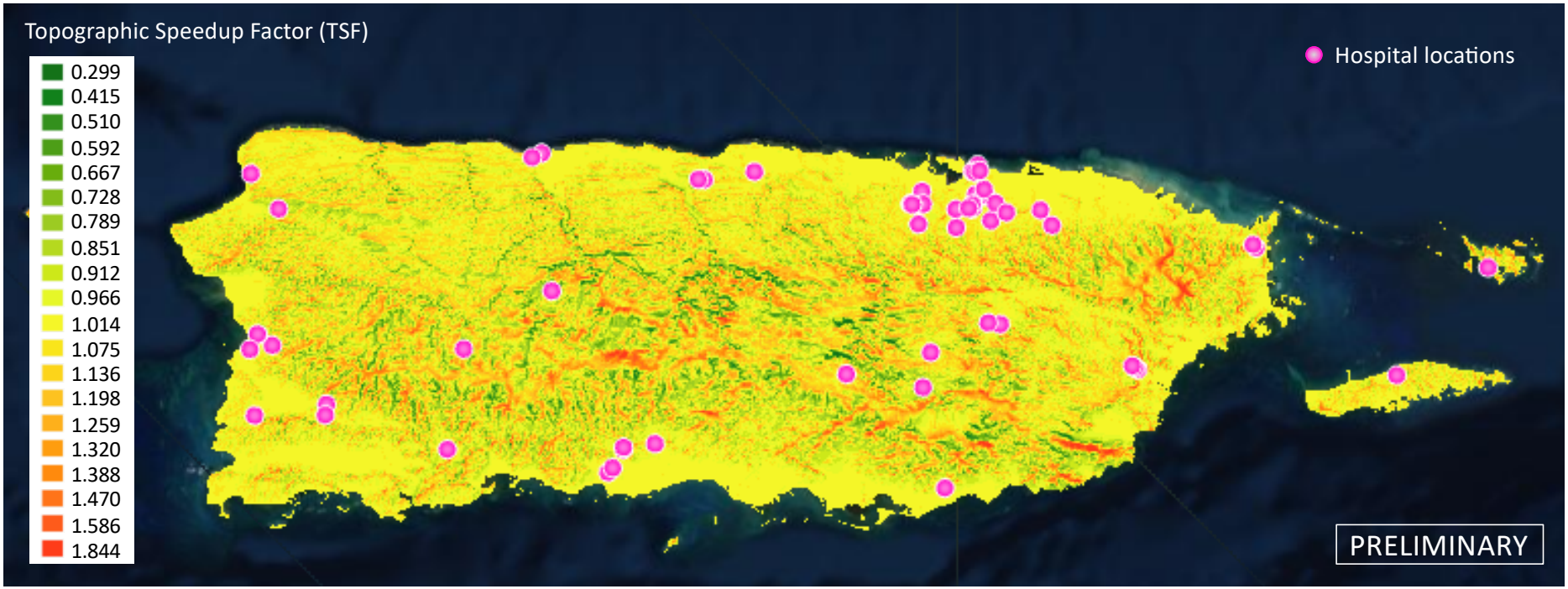
- Wind hazard exposure is a key consideration for the building sample selection
- Graphic shows peak gust wind speeds, including topographic effects
- Results are preliminary, from the initial wind field model



Wind Hazard Characteristics at Hospital Sites

Preliminary results from initial wind field model:

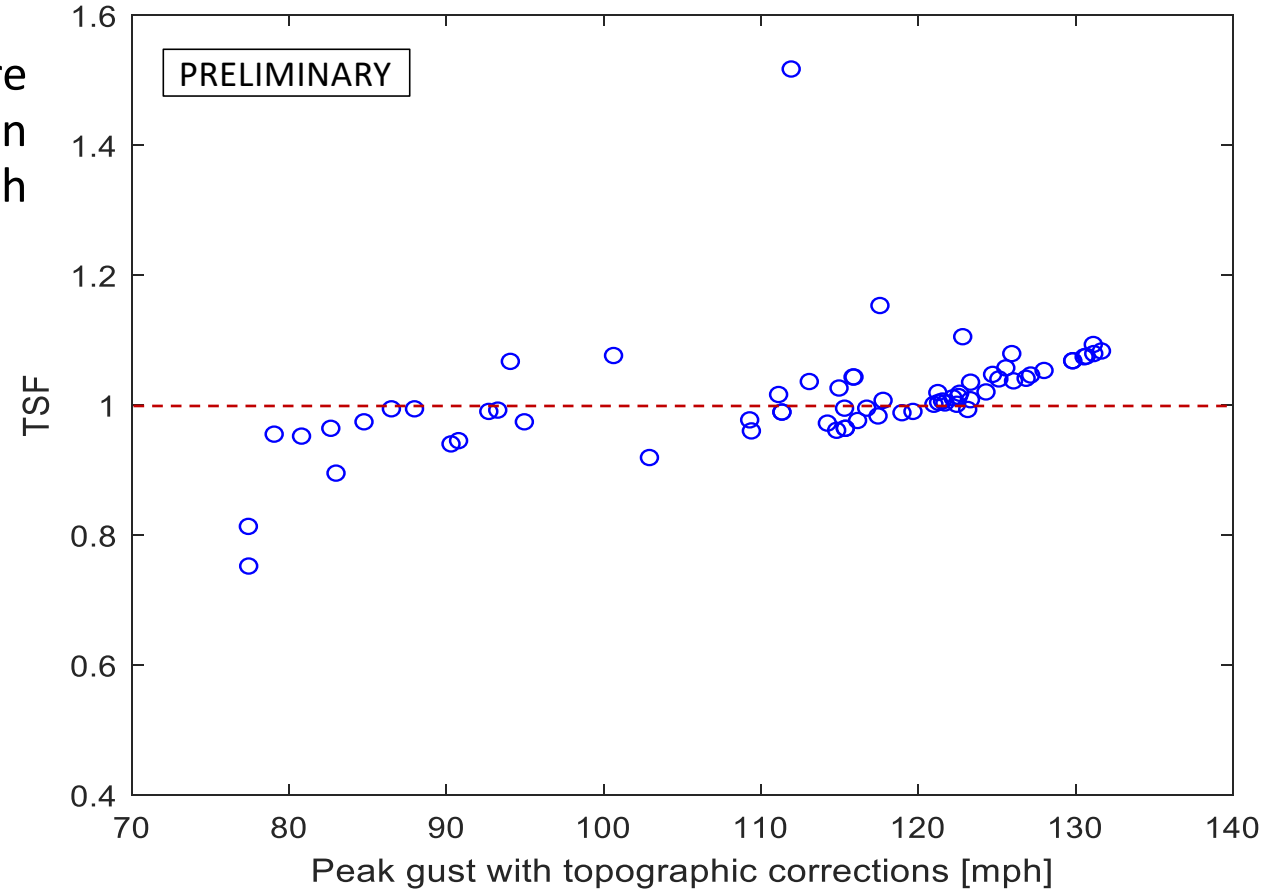
$$\text{Topographic Speedup Factor} = \frac{\text{Peak Gust Wind Speed with Topographic Corrections}}{\text{Peak Gust Wind Speed without Topographic Corrections}}$$



Wind Hazard Characteristics at Hospital Sites

Topographic speedup factor* vs. peak gust wind speed, including topographic effects:

* The TSF value plotted here corresponds to the direction of the largest peak gust with topographic corrections



Next Steps

- Continue collection of documents and information on building characteristics, hazard exposure, damages, and loss of function:
  - to guide the sample selection
  - to inform building evaluations and reduce the amount of information to be collected in the field
  - to inform the evaluation of storm shelter selection criteria and design requirements
- Evaluation of buildings:
  - Establish an initial sample of buildings for evaluation
  - Award contract for local engineering services
  - Develop workplan for evaluations and coordinate with relevant agencies and facility managers
  - Perform evaluations
- Wind tunnel testing of buildings:
  - Select two buildings and establish requirements for building and area models
  - Establish requirements for approach flow conditions and measurements and perform testing
  - Combine measured data with time-dependent hurricane wind-field model to evaluate wind load histories for Hurricane Maria

Thank you!

For questions, please contact:

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