NIST National Construction Safety Team Investigation of Hurricane Maria

NCST Advisory Committee Meeting – March 2024

Summary of Progress

Maria Dillard

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

Presentation Outline

1. Program Overview
2. Progress Highlights
3. Contracting Updates
4. Staffing & Stakeholder Outreach
5. Preview of Themes
6. Acknowledgements

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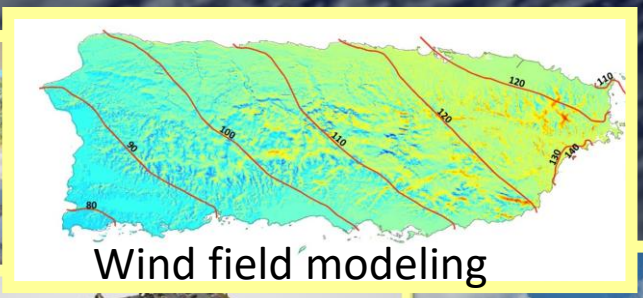
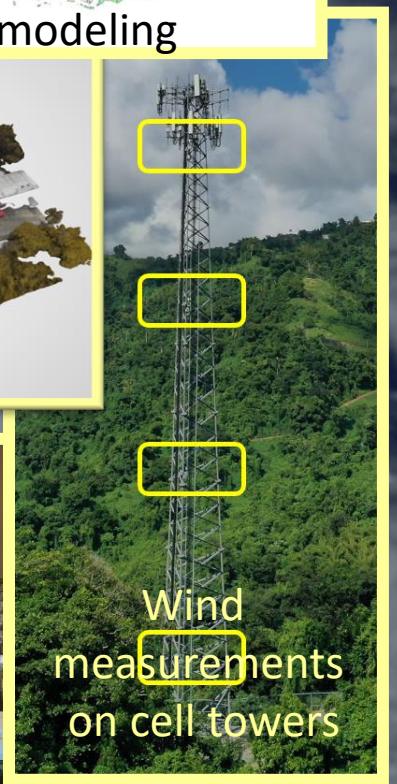
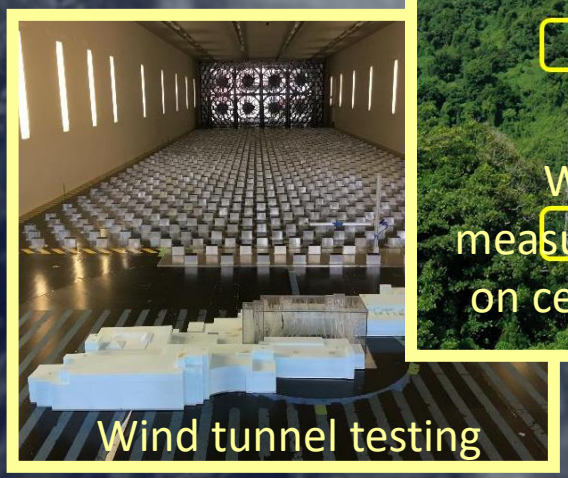
Hurricane Maria Program

Event Impacts

Recommendations







Investigation

Hurricane Maria Program

2 Program Components

NCST Investigation	NWIRP* Research Study

7 Technical Projects

Hazard Characterization	Performance of Critical Buildings	Public Response to Emergency Communications	Morbidity & Mortality	Impacts to and Recovery of Infrastructure Systems	Recovery of Business and Supply Chain	Recovery of Social Functions

5 Major Contracts

Applied Research Associates	University of Florida	Stantec Consulting	George Washington University	Horsley Witten Group

Multiple Collaborating and Coordinating Agencies

FEMA	NOAA	HHS	USGS	NCDMHP	PRDOH	PRDOE	PRDTOP	PRASA	PRFAA	Many others…

1 Coordinated Program

*National Windstorm Impact Reduction Program

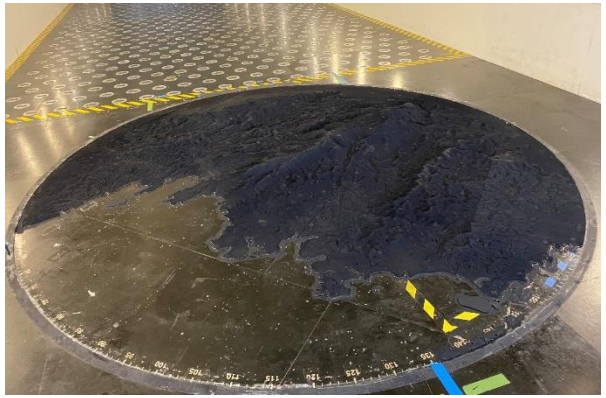
NCST Investigation Goals and Projects

***Goals** 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.*

Projects:

Hazard Characterization	Performance of Critical Buildings	Public Response to Emergency Communications	Morbidity & Mortality



NWIRP Research Study Goals and Projects

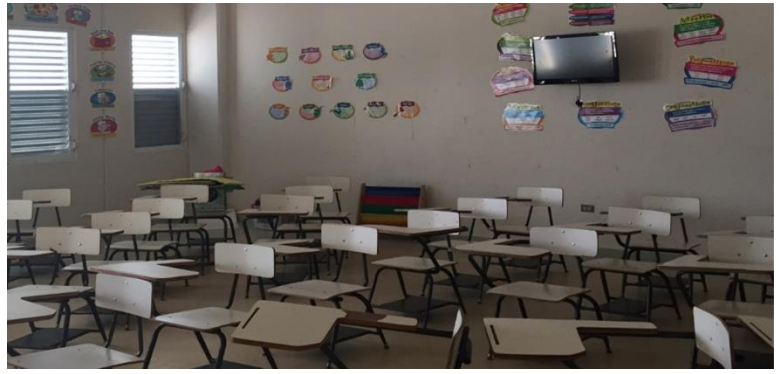
***Goals** are to characterize the impacts to and recovery of:*

1. *small and medium-sized manufacturers, businesses in retail and service industries, and supply chains;*
2. *education and healthcare services; and*
3. *infrastructure systems, with a focus on infrastructure that supports critical buildings (i.e., hospitals and schools) and emergency communications.*

Projects:

Recovery of Business & Supply Chains

Recovery of Social Functions



Impacts to & Recovery of Infrastructure Systems

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NCST Data Collection Status: *Completed*

Hazard Characterization

- Wind Tunnel Testing of Topographic Models — *University of Florida*
- Meteorological Data for Wind Field Model — *Applied Research Associates*
- Field Measurements of Winds on Cell Towers (2+ years) — *University of Florida / WeatherFlow*
- Data on rainfall, storm surge, flooding and landslides

Public Response to Emergency Communications

- Information Provider Interviews — *Horsley Witten*
- Household Surveys — *Horsley Witten*
- Public Messages for Qualitative Content Analysis
- Household Interviews — *Horsley Witten*

Performance of Critical Buildings

Facility Evaluations: 5 hospitals, 5 shelters

- Phase 1: Document collection and review
- Phase 2: Site visits and interviews

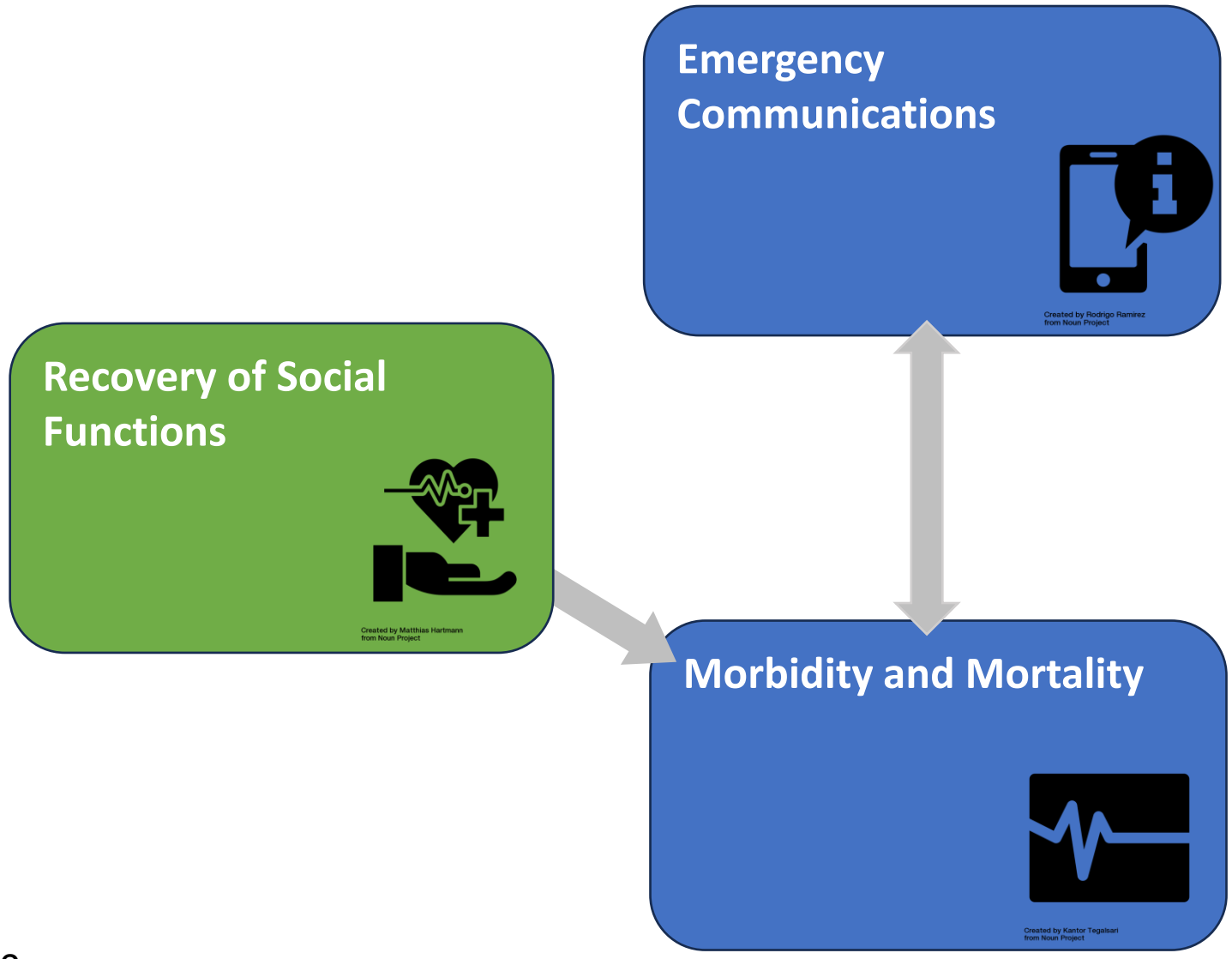
Stantec Consulting

- Wind Tunnel Testing of Two Hospitals — *University of Florida*

Morbidity & Mortality

- Verbal Autopsy and Social Environmental Survey — *GW-UPR*
- Integrated Database of Deaths in Puerto Rico — *GW-UPR*
- Medical Records and Hospital Functions Review — *GW-UPR*
- Spatial and Temporal Data for Analysis of Deaths — *GW-UPR*

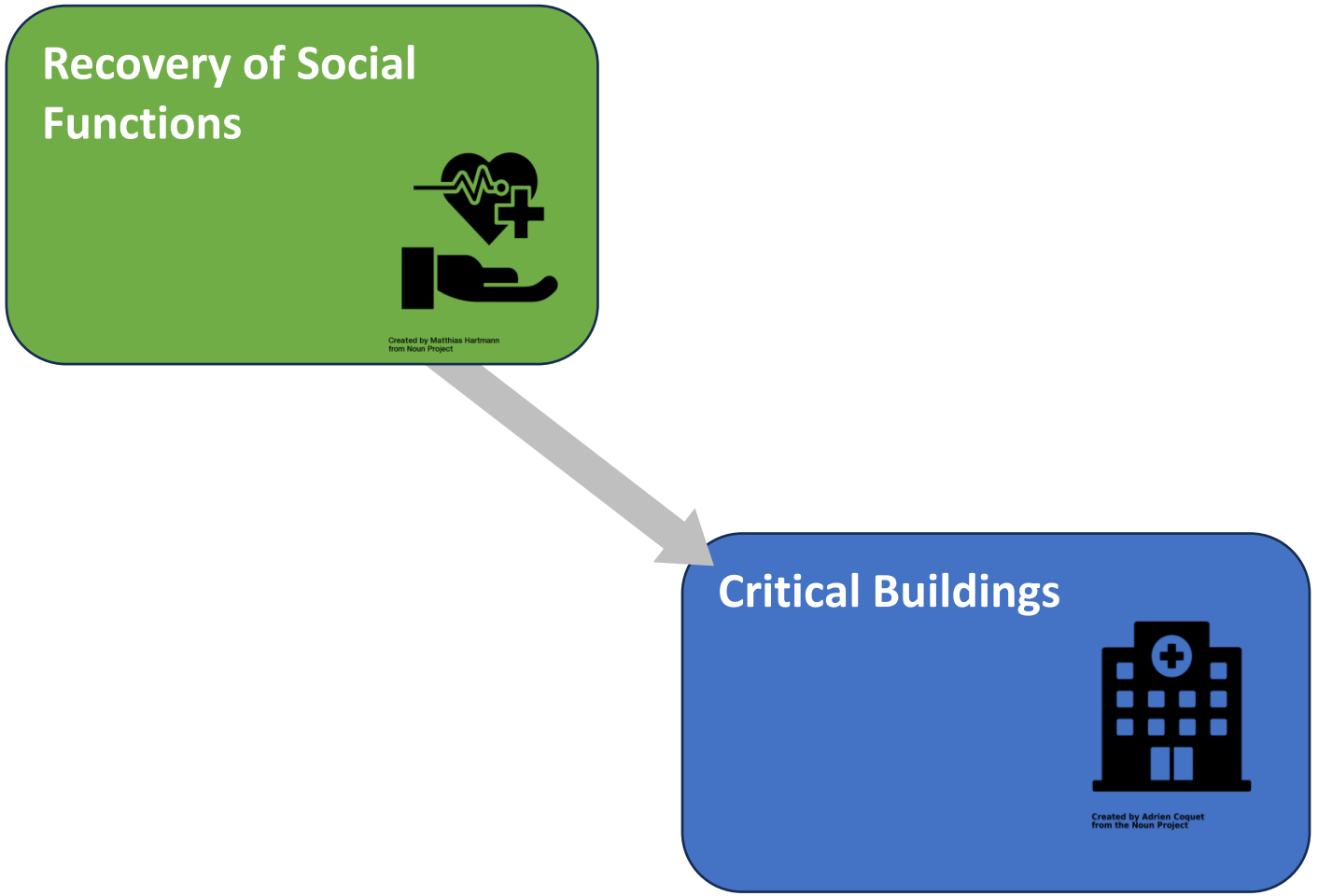
NCST Data Analysis Status: *In Progress*



Integration Models:

- The Recovery of Social Functions Project is providing data on hospital function, deaths, and injuries to the Morbidity and Mortality Project
- The Emergency Communications and Morbidity and Mortality Projects are conducting analysis of crossover topics such as preparedness of households and evacuation decisions that may have impacted deaths and injuries
- Approach involved
  1) Selecting a team member to work across projects to identify relevant data and facilitate analyses needed for the development of findings and recommendations
  2) Biweekly meetings of the project leads and team member

NCST Data Analysis Status: *In Progress*



Integration Models:

- The Recovery of Social Functions Project is providing damage data on schools and hospitals as well as hazard exposure data to inform a broader understanding of building impacts and performance across Puerto Rico
- Approach involved
  1) Selecting a team member to work on both projects to identify relevant data and appropriate analyses for the development of findings and recommendations
  2) Meetings of liaison team member with each project team to ensure information flow

Progress by the Numbers (since Sept. 2023)

1000+

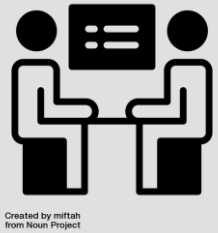
PAGES OF CONTRACTOR REPORTS REVIEWED

ON NCST AND NWIRP PROJECTS

87

TERABYTES OF DATA

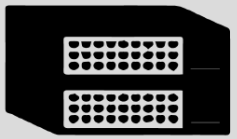
ON WIND TUNNEL TESTS



18+

MEETINGS WITH STATISTICIANS

ON ANALYSIS DECISIONS, UNCERTAINTY QUANT.



1.7M

TOTAL COMPUTATIONAL TIME, CPU Hrs

ON COMPUTATIONAL FLUID DYNAMICS MODELS

8

DATASETS THROUGH QAQC REVIEW

ON HAZARDS, EMERGENCY COMMS, AND RECOVERY OF SCHOOLS, HOSPITALS AND BUSINESSES

35+

HOURS OF INTERVIEW DATA CODED

ON EMERGENCY COMMUNICATIONS AND RECOVERY OF SOCIAL FUNCTIONS

Statistical Analysis Support

Uncertainty

Goal: to determine the degree of confidence in the output of an analysis or model

Weighting

Goal: to improve the generalizability of survey estimates

Imputation

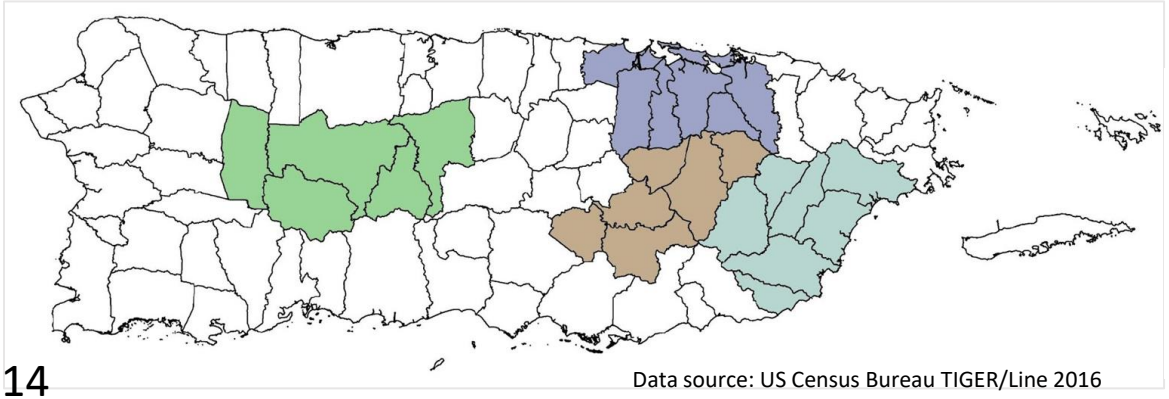
Goal: to fill in missing data and therefore, to retain as many cases as possible during analysis

The Statistical Engineering Division is supporting the Hurricane Maria Team through engagement in analysis plans, review of data and results, and expert input.

Sample Weighting for Household Surveys

Household Survey on Emergency Communications – Background:

- Responses provide detailed information on:
  - Receipt of emergency communications
  - Evacuation behavior and decision-making
- Over 1500 households responded across 4 study regions
- Overall response rate of 26.6%



Data source: US Census Bureau TIGER/Line 2016

Sample Weighting for Household Surveys

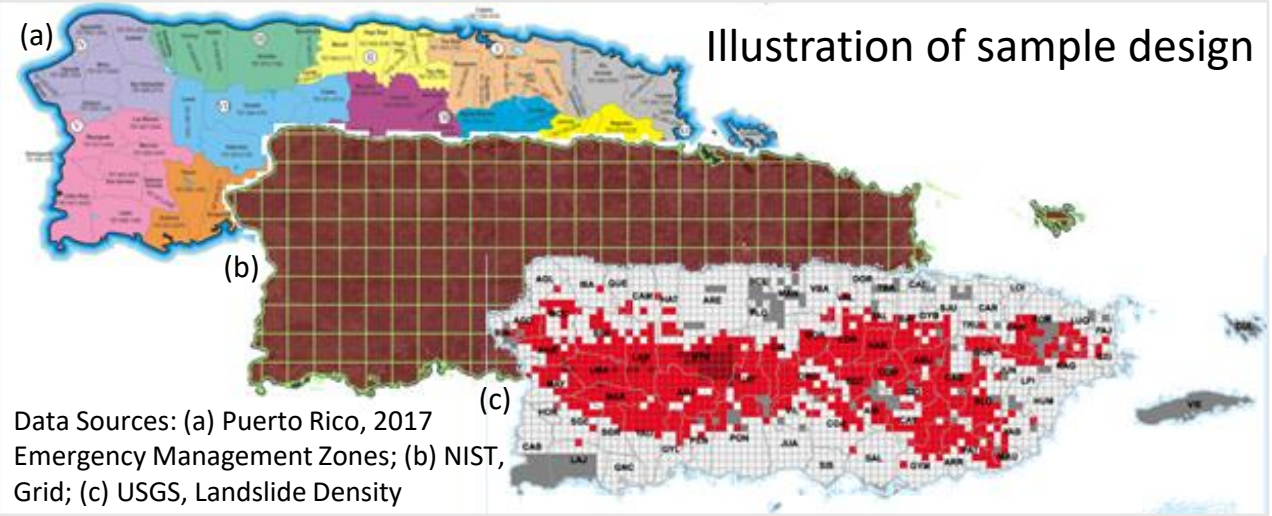
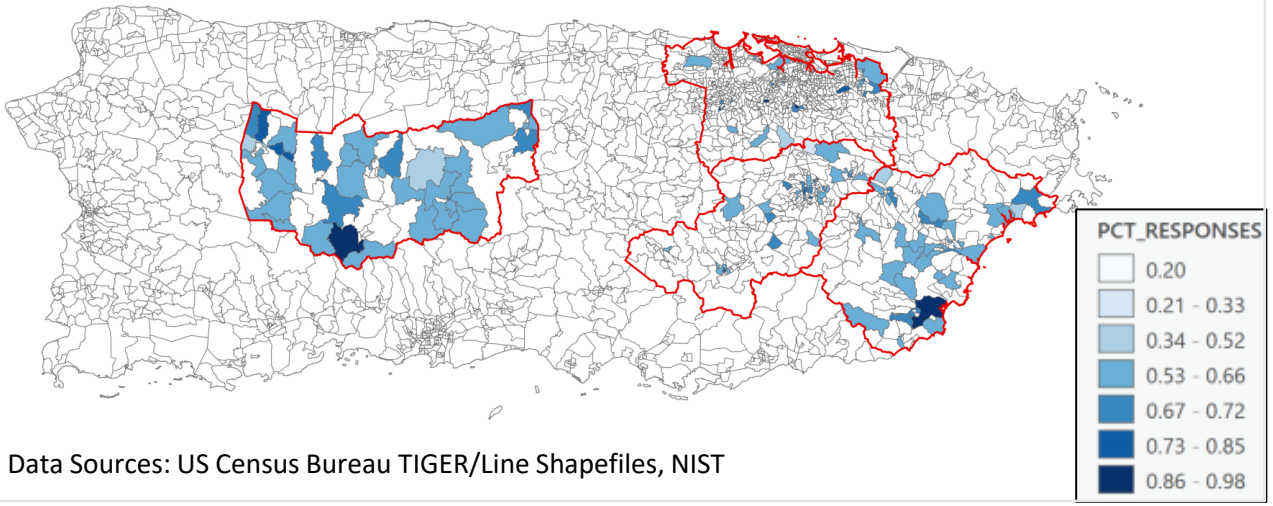


Illustration of sample design

Data Sources: (a) Puerto Rico, 2017 Emergency Management Zones; (b) NIST, Grid; (c) USGS, Landslide Density

Percentage of survey respondents by Census Block Groups



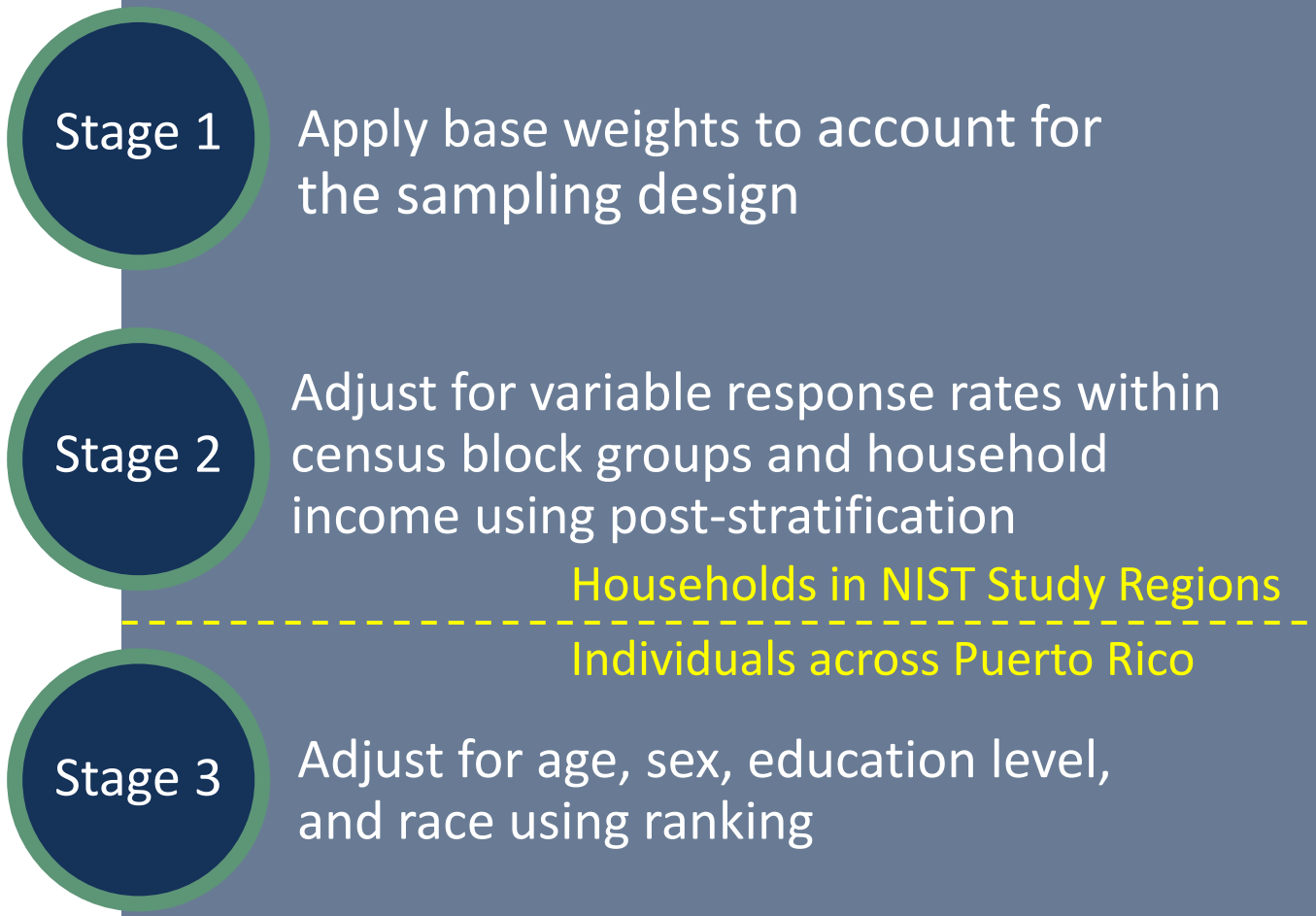
Data Sources: US Census Bureau TIGER/Line Shapefiles, NIST

Weights are being used to develop estimates with corresponding error terms for the population of Puerto Rico

- Weights are necessary because of:
  - Sample design
    - Accounted for key variables such as flood and landslide risks and socioeconomic status
  - Survey non-response
    - Response rates differed by census block group, region, and demographics

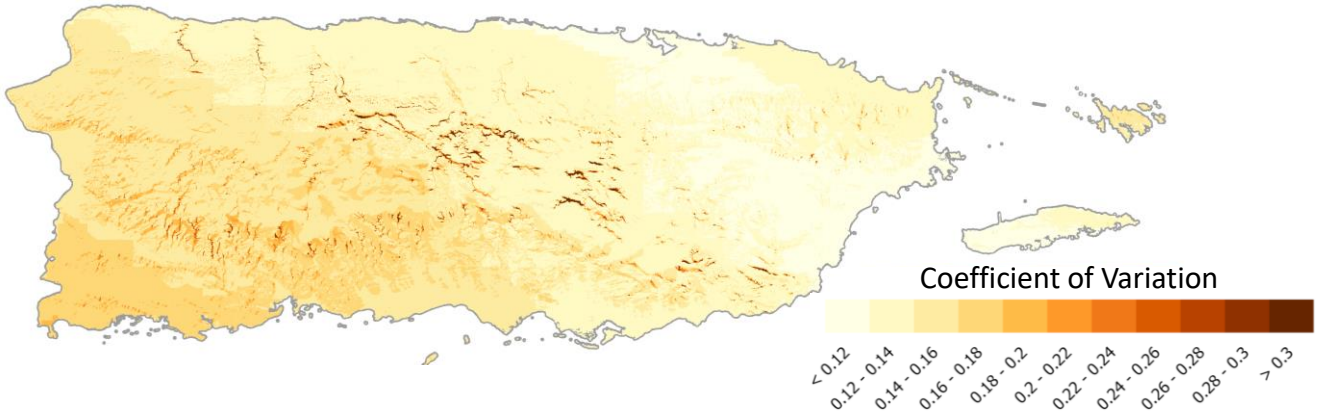
Sample Weighting for Household Surveys

- The weighting plan involves two sets of weights:
  - (Set 1) Household level within the sampling regions
  - (Set 2) Individual level across Puerto Rico
- Weighting allows:
  - For the generalizability of the survey results to the four sampling regions (Set 1) and all of Puerto Rico (Set 2)
  - For accurate estimation of uncertainty accounting for the sampling design and non-response

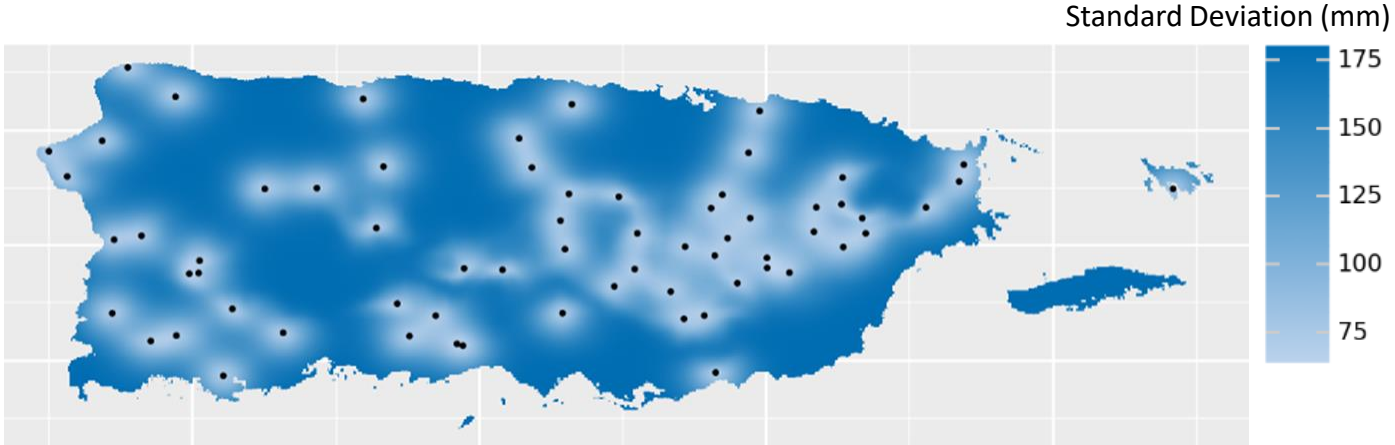


Uncertainty Quantification for Hazards

Uncertainty Estimates for Peak Wind Speed



Uncertainty Estimates for Total Rainfall



- **Wind-field model:** Uncertainty estimates for modeled wind speeds based on differences between models and measurements, including consideration of uncertainty in topographic speedup factors
- **Rainfall:** Gaussian process regression used for interpolation of rain gauge data and quantification of uncertainty using a leave-one-out (LOO) cross-validation method

PRELIMINARY ANALYSIS

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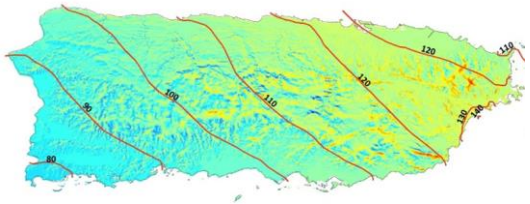
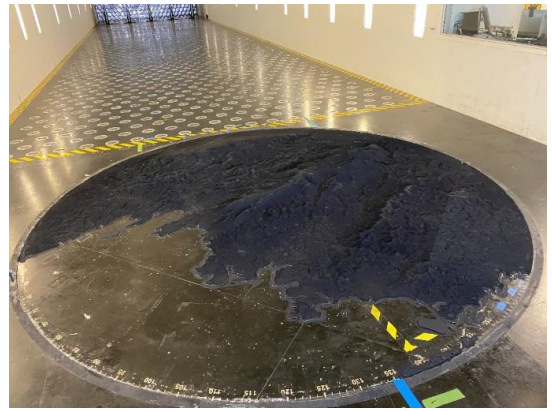
Supporting Contracts

Contract
Wind Field Modeling
Wind Tunnel Testing and Field Measurement of Winds
Engineering Services to Evaluate Critical Building Performance
Social Science Data Collection
Morbidity and Mortality Assessment



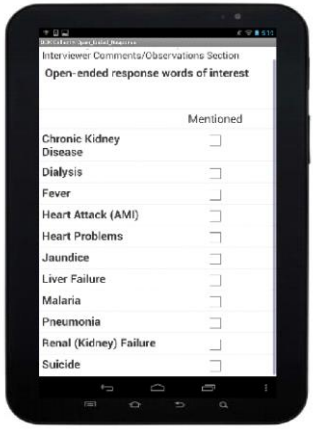
Applied Research Associates



University of Florida

Stantec Consulting

Horsley Witten Group



Source: Bernardo Hernández Prado

GW/UPR

Supporting Contracts: Updates

Status	Contract	Contractor(s)	Project(s) Supported
Modification (awarded 3/2024)	Engineering Services to Evaluate Critical Building Performance	Stantec Consulting Services, Inc.	• Critical Buildings
Modification (in progress)	Social Science Data Collection	Horsley Witten Group, Inc. • Eastern Research Group • Issues and Answers • Albizu University (San Juan)	• Emergency Communications • Recovery of Business • Recovery of Social Functions • Infrastructure Systems
New Contract (in preparation)	Technical Report Preparation	TBD	• All projects of the NCST Investigation and NWIRP Research Study
Modification (awarded 12/2023)	Stakeholder Outreach Support	Strativia, LLC	• All projects of the NCST Investigation and NWIRP Research Study

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Staffing

- **Dr. Brian Phillips** at University of Florida was hired through an IPA starting in December 2023; Dr. Phillips is supporting the Hazard Characterization and Critical Buildings Projects.
- Hurricane Maria Program will partially support a new hire with **GIS expertise**; hiring package and recruitment efforts are in progress.
- Onboarding new **NIST Associates** appointed under the Professional Research Experiences Program (PREP) to support key data analysis activities.
- Additional staffing appointments are underway to provide **support for data analysis and report writing** in areas of specific expertise including public health and epidemiology, qualitative data analysis, and statistical analysis.

Hurricane Maria Project Leaders, June 2023

Stakeholder Outreach

1 Interagency Efforts

December 2023 marked the conclusion of the Fast-Track Action Committee (FTAC) on Data Infrastructure for Puerto Rico, established by the National Science and Technology Council

2 Presentations

International Conference on Wind Engineering (August 2023)

International Conference on the Environment, Work & Health in the 21st Century: Strategies and Solutions to a Global Crisis (October 2023)

International Code Council (February 2024)

3 Ongoing Engagement

Coordination with Puerto Rico Hospital Association (AHPR) to support increased response rates for interviews and Wave 2 hospital surveys on recovery of social functions

Coordination with Department of Transportation and Other Public Works and related transportation agencies, PRASA, RCAP-Solutions, LUMA/PREPA for infrastructure interviews

4 Upcoming Engagement

Special session accepted for the Conferencias Puertorriqueñas de Salud Pública on methods used for Morbidity and Mortality Project and public health context of Puerto Rico, to include team members from The George Washington University and University of Puerto Rico (May 2024)

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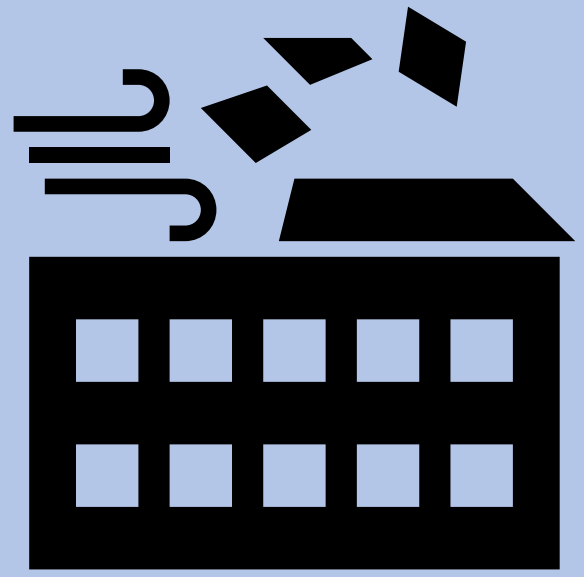
Panel Presentation Themes

Subsequent panel presentations are organized around these cross-cutting themes:

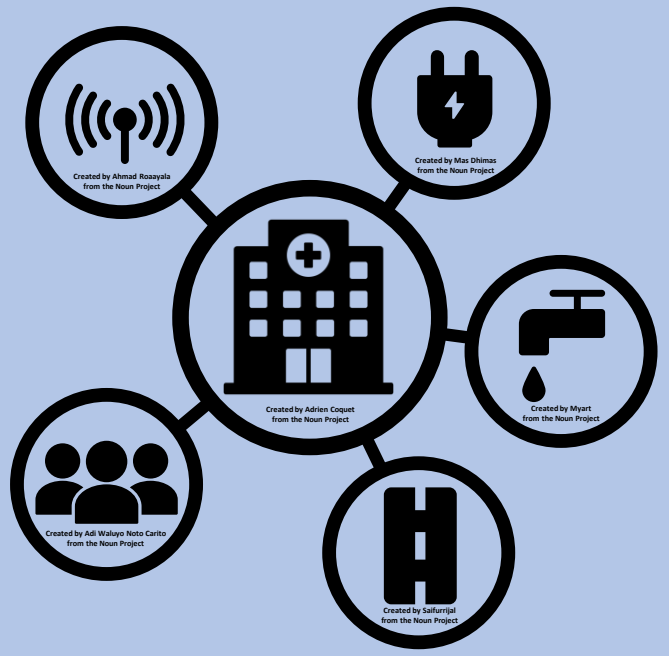
Theme 1: *Hazard Exposure*



Created by Arthur Shlain
from the Noun Project

DongHun Yeo, Marc Levitan, Maria Dillard

Theme 2: *Hospital Functionality & Infrastructure Dependencies*



Maria Dillard, Joseph Main, Ken Harrison

Theme 3: *Protective Action & Preparedness*

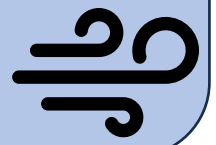
Created by Good Father
from Noun Project

Jennifer Helgeson, Katherine Johnson, Marc Levitan, Judith Mitrani-Reiser

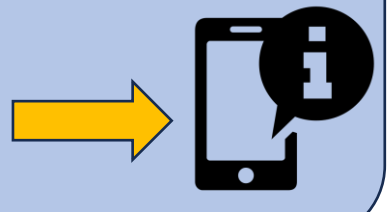
Integration of Data Streams

EXAMPLE - Data streams featured in Cross-Project Panel Theme 1:

Hazard Characterization
Wind-field model
Rainfall dataset & regression model
Landslide density
Flood model

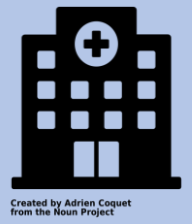


Emergency Communications
Surveys with households
(1523 households)



Recovery of Social Functions
Surveys with Hospital Administrators
(16 hospitals)

Critical Buildings
Interviews with hospital engineers or administrators
(5 hospitals)
Wind tunnel test data
(2 hospitals)



Recovery of Infrastructure
Aerial imagery for tower sites
(600+ sites)

Recovery of Business
Surveys with businesses
(451 businesses)

Note: the subject of the data collection may be represented with a unique identifier code to avoid identification. These codes are distinct across projects.

Disclaimers for Presentations

⚠ IMPORTANT: ALL DATA ARE PRELIMINARY

- These presentations describe preliminary data gathered to date as well as preliminary analyses of these data. Data and analyses are subject to change.
- Once all data are finalized and analyzed, they will inform a broader understanding of Hurricane Maria's effects on Puerto Rico and subsequent recovery– and NIST's findings and recommendations.
- These presentations do not constitute NIST findings or recommendations.
- All survey and interview data collection included a consent process that specifies the allowable uses of data and protections of respondents.
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Acknowledgements

To all those in Puerto Rico who responded to the data collection requests and shared knowledge, experiences, and lessons learned, including:

- Households
- Families and loved ones of those who lost their lives
- Emergency information providers
- Business owners and managers
- Shipping and transport operators
- Hospital administrators and staff
- School administrators and staff
- Shelter operators
- Infrastructure operators

To all those impacted by Hurricane Maria

To our dedicated team who continue to demonstrate great perseverance, including:

- NCST Members
- Technical Staff
- PREP Associates
- Contractor Teams
- Institutional Support

To our many partners in Puerto Rico who have supported our data collection efforts.

Questions?

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Associate Team Lead
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www.nist.gov/topics/disaster-failure-studies/hurricane-maria

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