NIST National Construction Safety Team Investigation of Hurricane Maria
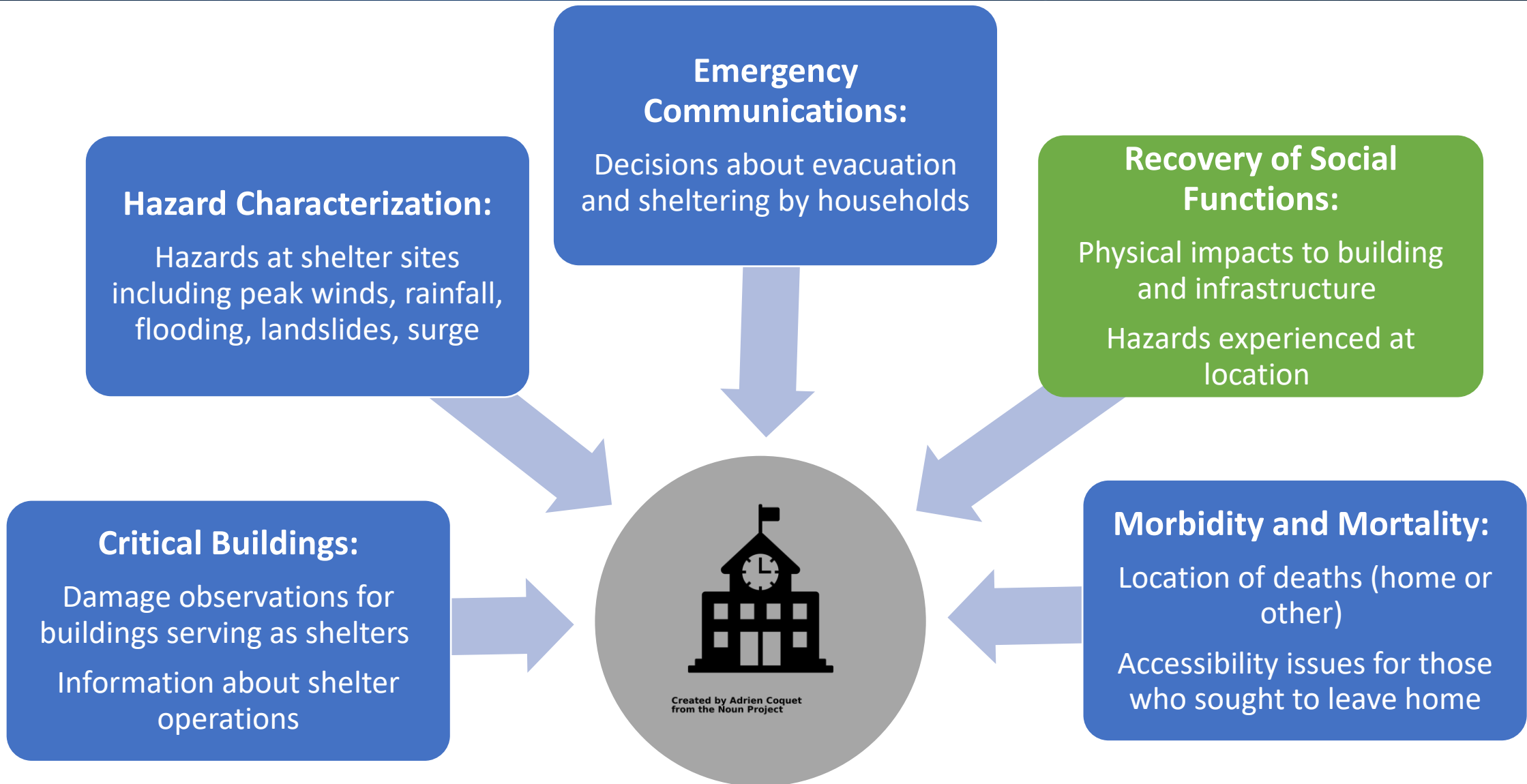
NCST Advisory Committee Meeting – June 14, 2023

Cross-Project Panel Theme 2: Sheltering
Marc Levitan, Katherine Johnson, Maria Dillard

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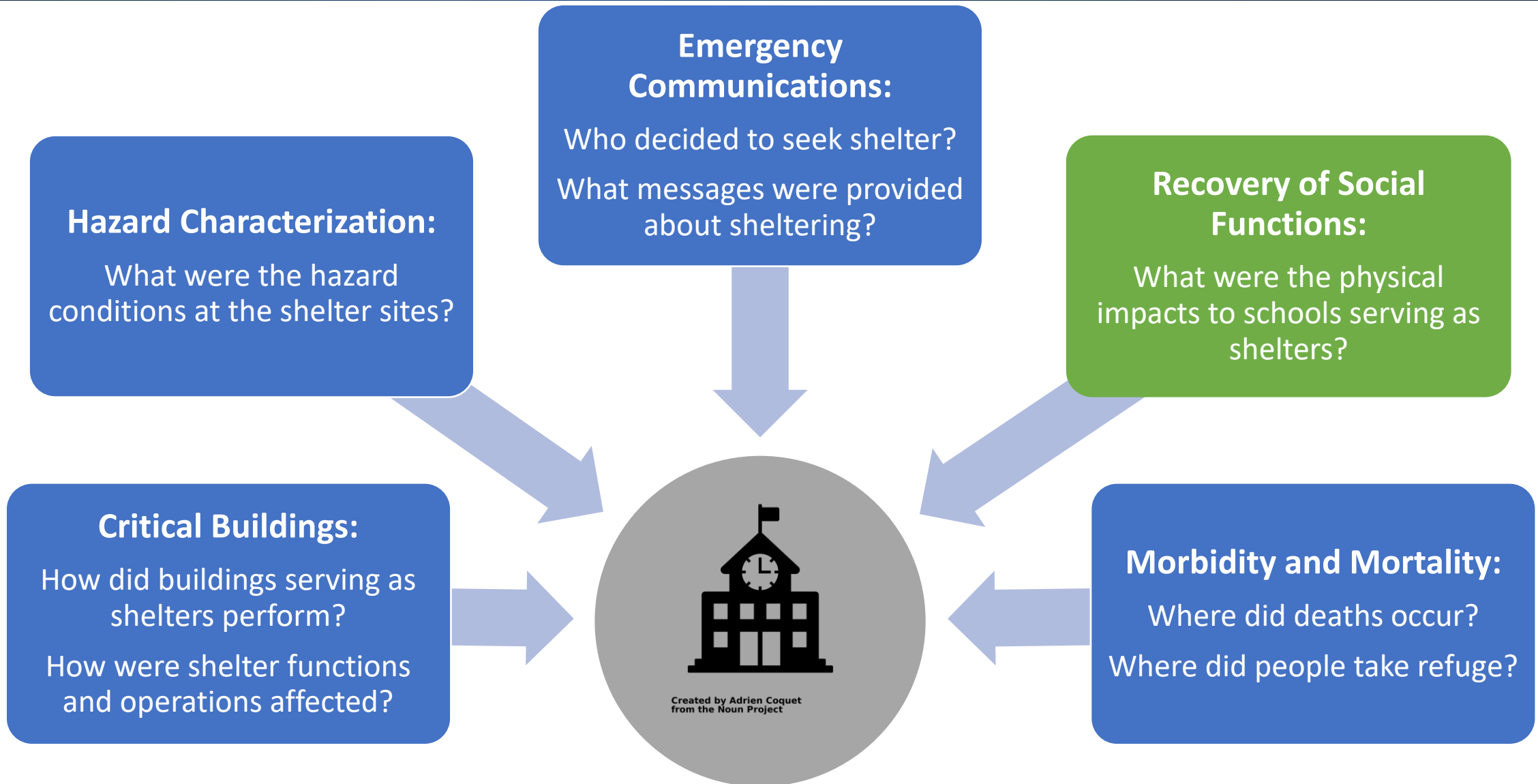U.S. DEPARTMENT OF COMMERCE

Sheltering Theme: Motivation

- Preliminary reconnaissance identified issues related to evacuation and response:
  - People in flood zones were urged to evacuate and move to shelters along with residents in certain types of structures (e.g., wood framed houses)
  - Emergency information was provided via multiple channels, by multiple sources (e.g., NWS, Commonwealth and local governments, media)
  - Many people had to be rescued from flooding in multiple towns
  - Shelter populations continued to inhabit schools months after landfall, delaying resumption of normal education services

- The NCST Act mandates NIST to "…evaluate the technical aspects of procedures used for evacuation and emergency response" as well as to "recommend specific changes to building codes, standards and practices".

- The Hurricane Maria NCST Investigation builds upon NIST's Joplin Tornado NCST Investigation to inform procedures used to designate shelters as well as codes and standards for buildings serving as shelters.
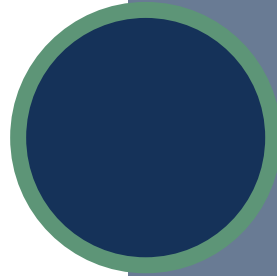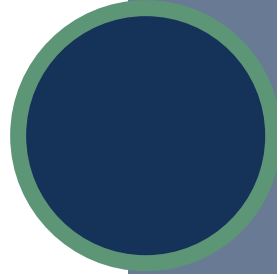
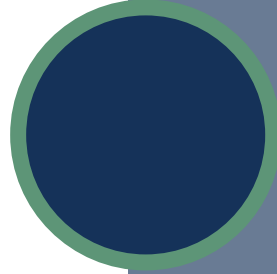# Sheltering Theme: Integration of Data Streams

Emergency Communications:

Decisions about evacuation and sheltering by households

Hazard Characterization:

Hazards at shelter sites including peak winds, rainfall, flooding, landslides, surge

Recovery of Social Functions:

Physical impacts to building and infrastructure

Hazards experienced at location

Critical Buildings:

Damage observations for buildings serving as shelters

Information about shelter operations

Morbidity and Mortality:

Location of deaths (home or other)

Accessibility issues for those who sought to leave home

Created by Adrien Coquet from the Noun Project

Sheltering Theme: Integration of Analysis

NIST

Emergency Communications:

Who decided to seek shelter?

What messages were provided about sheltering?

Hazard Characterization:

What were the hazard conditions at the shelter sites?

Recovery of Social Functions:

What were the physical impacts to schools serving as shelters?

Critical Buildings:

How did buildings serving as shelters perform?

How were shelter functions and operations affected?

Morbidity and Mortality:

Where did deaths occur?

Where did people take refuge?

Created by Adrien Coquet from the Noun Project

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Sheltering Theme: Highlighted Projects
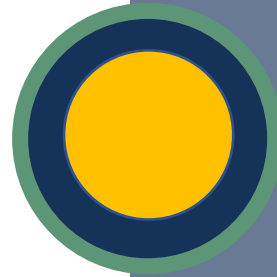

- Emergency Communications

- Critical Buildings

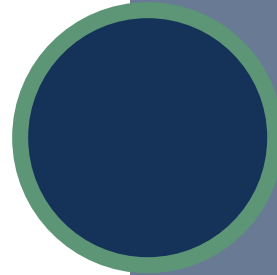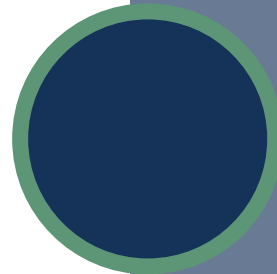- Recovery of Social Functions

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Sheltering Theme: Highlighted Projects

Emergency Communications

Critical Buildings

Recovery of Social Functions

Pre-Storm Messaging About Sheltering

NIST

NOAA

- If evacuating or relocating to a shelter, leave early before weather conditions become hazardous [Sep. 18]
- If you have doubts about whether you will be in a flooded area or in danger of mudslides, you should seek shelter from Hurricane Maria early—before winds and rains commence. [Sep. 19]
- Particularly dangerous situation—seek higher level within the shelter now! [Sep. 20]

NEWS

- Estimates (for Ponce): 11k in flood-prone areas; 4k will seek refuge in state shelters [PR, Sep. 18]
- First option should be to take refuge in the home of family or friends [PR, Sep. 19]
- Citizens refusing relocation to a shelter had to *"sign a document"* [El Vocero, Sep. 20]

Twitter

- Encouraging evacuation to shelters; noting capacities and number of shelters [Sep. 17]
- Lists of shelters circulating and messages encouraging people to know their zones and evacuate to the appropriate places [Sep. 19]
- No more beds or cots available and people are sleeping on the ground [Sep. 19]

Insight on Shelter Population Trends

Twitter

Sep. 17   As of 12:35 PM, there are **192** refugees remaining after the passage of Hurricane Irma

Sep. 19   As of 7:00 AM, there are **299** refugees in Puerto Rico, and that number will rise significantly

As of 8:00 PM, there are **4,422** refugees and 105 pets

Sep. 20   As of 2:06 AM, there are **7,144** refugees and 288 pets in 146 shelters

As of 5:00 AM, there are **11,229** refugees and 580 pets

NEWS

Sep. 17   133 are from *repatriates from neighboring islands*, 51 from Canóvanas and 8 from Vieques (**192**)

Sep. 19   In Salinas there are 27 refugees, in Ponce 104, in the Convention Center 121, and in Canóvanas 50 (**302**)
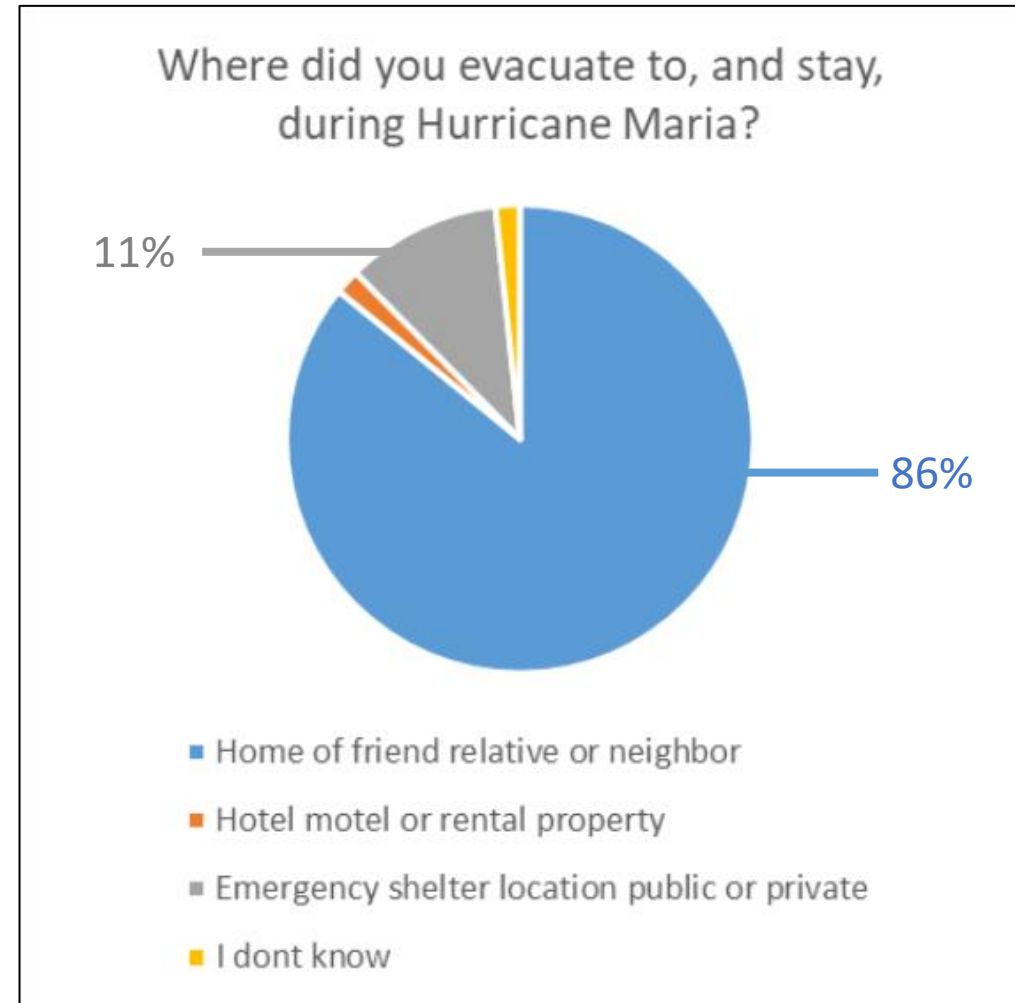
Department of Housing reported there are **373** people in 15 of the *500 shelters enabled by the State*

Shelter Related Content from IP interviews

- National Hurricane Center and National Weather Service reported messaging targeting <u>threat from hazards</u> (wind, rain, flooding, etc.); emphasizing <u>seriousness of threat</u>; being an aid to local decision-making

- Media distributed messages about <u>shelter locations</u>, instructing people to find strong shelters

- Mayors and local government representatives emphasized evacuation for people in <u>deficient structures</u> and for those with <u>health care needs</u>; use of civil servants to inform and promote evacuation; transportation provided to some; and also reported insufficiencies with shelter facilities and supplies (power, water, beds, sanitation, etc.)

PRELIMINARY DATA ANALYSIS

Evacuation Behavior of Survey Respondents

- A majority of sampled households reported they did <u>not</u> evacuate

- Most evacuees sought refuge at the home of a friend, relative, or neighbor

- 11% of <u>evacuating</u> respondents went to an emergency shelter

- Those that evacuated were asked about where they sought shelter (see pie chart)

Where did you evacuate to, and stay, during Hurricane Maria?

11%

86%

- ■ Home of friend relative or neighbor
- ■ Hotel motel or rental property
- ■ Emergency shelter location public or private
- ■ I dont know
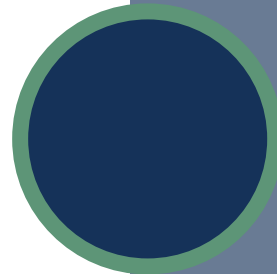
PRELIMINARY DATA ANALYSIS

Sheltering Theme: Highlighted Projects
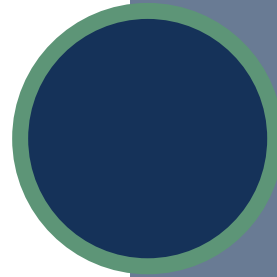
- Emergency Communications
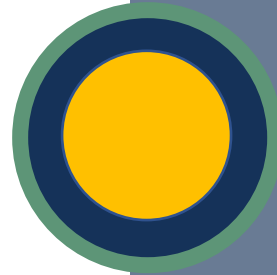
- **Critical Buildings**

- Recovery of Social Functions

Shelter Damage Observations

- Common themes at 5 selected shelter facilities: (preliminary observations from Phase 1 evaluations)

  – Water intrusion and damage to building contents reported for all but one of the buildings

  – Minor exterior wall damage was reported for most of the buildings

  – Roof covering damage

  – Broken/damaged windows

  – Electrical damage (damage to AC units, electrical panels)

- Phase 2 site visits and interviews are underway

Phase 1: Initial document collection and review

Phase 2: Interviews, site visits, additional document review
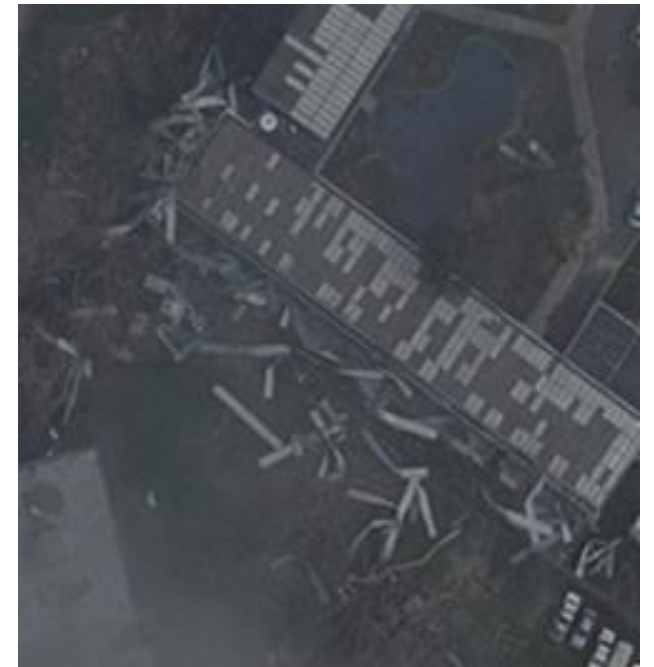
Credit: GIC/Vexcel

Estimation of Shelter Building Damage States

- Building Damage States estimated using Phase I evaluations

- To allow for comparison, NIST developed a damage state matrix to be applied across projects to hospitals, schools and businesses

- The damage state descriptions were informed by FEMA's Hazus and other literature
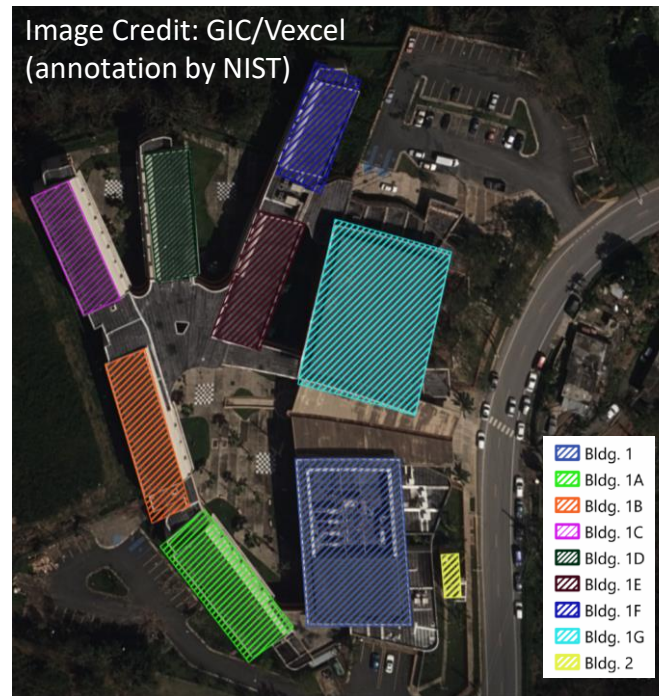
- **Example matrix for one shelter building shown**

DAMAGE DESCRIPTIONS

Building Components (CATEGORIES FOR ASSESSMENT)	0- None or Very Minor	1- Minor	2- Moderate	3- Severe	4-Complete Destruction	Don't Know
Damage to Roof Cover, % of roof area	0% (no damage) to 2%	3% to 15%	16% to 50%	51% to 100% (complete loss)	---	DK
Damage or Loss of Roof Decking and/or Roof Structure, % of roof area	0% (No damage)	0% (No damage)	1% to 10%	11% to 25%	26% to 100% (complete loss)	DK
Broken Windows and Doors, amount or %	None	Few	Many (up to 50%)	Most or all (51% to 100%)		DK
Damage to Exterior Walls	Little or no visible damage	Marks or dents or cracks requiring painting or patching for repair	Partial failure of 1 wall	Failure of 1 wall	Failure of more than 1 wall	DK
Damage to Interior Finishes, Contents, and Mechanical and Electrical Systems	None	Minor	Moderate	Severe	Complete	DK
% of building that had significant water intrusion	None	1% to 10%	11% to 25%	26% to 50%	(51% to 100%) see note above	DK

PRELIMINARY DATA ANALYSIS

Shelter Functionality and Operations

Common themes at some of the selected shelter facilities:
(preliminary observations from Phase 1 evaluations)

- Overcapacity

- Prolonged duration of occupancy

- Impacts to resumption of normal function and operation of the facilities used as shelters

Image Credit: GIC/Vexcel (annotation by NIST)

Bldg. 1
Bldg. 1A
Bldg. 1B
Bldg. 1C
Bldg. 1D
Bldg. 1E
Bldg. 1F
Bldg. 1G
Bldg. 2

Image Credit: GIC/Vexcel (annotation by NIST)

Basketball Pavillion
Bldg. 1

Shelter Functionality and Operations

Common themes at selected shelter facilities: (preliminary observations)

- Flooding reported in designated shelter areas

- During the storm, shelter occupants were required to be relocated to other areas in the facility

"I thought my heart was going to stop … It was terrible: I was nervous, anguished, praying. A meter from where I was, a part of the ceiling fell. From there, they evacuated us to the bathroom, but there the dripping started, and they also took us out of there because it was no longer safe … The coliseum lamps fell. Everything was dreadful, as if it was shaking. The power went out, we were left without communication. Then the water started to come in and people started to get alarmed. At the end, the water rose up to our ankles …"

Carolina Cardozo
Shelter Occupant at Humacao Arena
As told to Julio Alvarado, EFE,
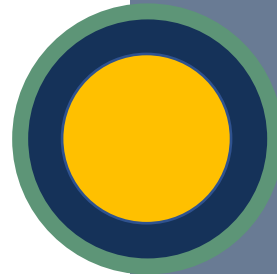published on Vanguardia.com on September 25, 2017

Sheltering Theme: Highlighted Projects
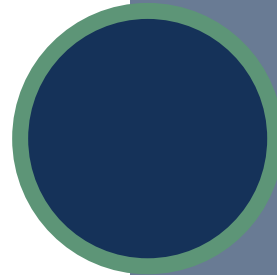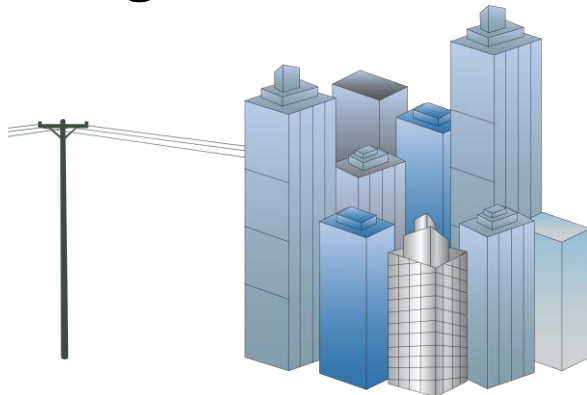
Emergency Communications

Critical Buildings

Recovery of Social Functions

Understanding the Performance of Schools
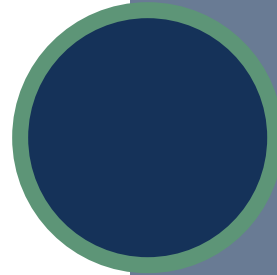
Critical Buildings Project
Explaining Building Performance

- Hazard exposure

- Building design and codes

- Structural and nonstructural damage

- Damage mechanisms

Recovery of Social Functions Project
Explaining Recovery of Social Functions

- Resources

- Resilience characteristics

- Physical and non-physical impacts of the hurricane

- Hazard exposure
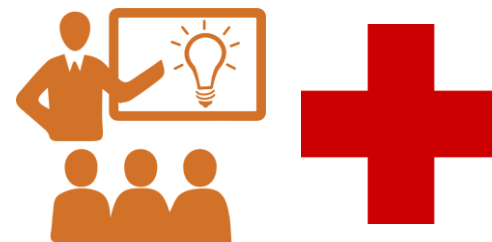
Municipalities with schools that responded to the Recovery of Social Functions Project Wave 1 Survey as shown in blue (NIST Study Regions shown in red). These schools will inform a broader understanding of building impacts and performance across Puerto Rico.

NIST

Physical Impacts to Schools

- Most schools reported that their campus suffered physical damage due to Hurricane Maria.

- Just under half experienced damage severe enough to cause complete closure.

- ~15% of schools that responded served as shelters.

- **Highlighted cells show modal response from preliminary analysis.**

PRELIMINARY DATA ANALYSIS

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		DAMAGE DESCRIPTIONS				
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	% of building that had significant water intrusion	None	1% to 10%	11% to 25%	26% to 50%	(51% to 100%) see note above	DK

Questions?

Theme 1: *Hospitals*

DongHun Yeo, Joseph Main, Judith Mitrani-Reiser

Theme 2: *Sheltering*

Marc Levitan, Katherine Johnson, Maria Dillard

Theme 3: *Infrastructure Dependencies*

Ken Harrison, Jennifer Helgeson, Maria Dillard