NWIRP Research Study of Hurricane Maria (Puerto Rico)

Infrastructure Systems Supporting Critical Buildings and Emergency Communications

Project Leader: Ken Harrison

Objective: From a study of power, water, transportation, and wireless communications infrastructure impacts, recovery, and decision-making, make recommendations for increasing resilience through changes to codes, standards and practice.
Background and Motivation: Importance of Dependencies on the Support of Critical Buildings

- Dependencies leading to loss of function
  - Propagation can impact the function of critical buildings
  - Redundancy can stem loss
- Dependencies in recovery phase, e.g.,
  - Repair of power lines can be dependent on road access

Hospitals and high-capacity water, power, and transportation links
“The term ‘resilience’ means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions.”


Prior Resilience State
- Prior codes, standards, and practice

Impacts
- Damage
- Cascading Damage / Loss of function

Recovery
- Temporary measures
- Critical path activities

New Resilience State
- New codes, standards, and practice
**Project Plan: Four Project Components**

**Dependencies**

*Objective:* Evaluate dependencies in power, water, and transportation infrastructure impacts, recovery, and decision-making.

- **Wireless Communications**
  *Objective:* Investigate causes of the loss of functionality and extended-duration outage of the wireless communication system in Puerto Rico following Hurricane Maria.

- **Integrative Study**
  *Objective:* In a case study for a community in Puerto Rico, evaluate the potential for model support of resilience decision-making.

- **Transportation Incident Analysis (new project component)**
  *Objective:* Mine the PR DTOP Transportation Incident Database to answer HM program questions.

**Transportation**

- Power
- Water
- Communications

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* Hurricane Maria NWIRP Research Study
## Project Plan: Data Collection and Analysis

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Recent Progress: Dependencies (1/3)
Recent Progress: Dependencies (2/3)

Primary Data Collection:
• Contact list for interviews (in progress)
  – Power (PREPA), water (PRASA) and transportation (DTOP), and at municipal level
  – In aggregate, 200 interviews of 1 hour duration
• Semi-structured Interview Instrument questions (in review; incorporating feedback)
Indicate the approximate time, as referenced from the time of HM landfall, that it took to reach the milestone of /critical buildings at 30% function/, which is defined here as meeting all of the following minimums:

- **Access:** 30% critical buildings receiving within /Caguas/
- **Reliability:** 30%-of-day, min 5 days/week
- **Quantity:** 30% of pre-HM total demand met
- **Quality:** commensurate with boil water advisory

Was restoration of /Power/ on the critical path to reaching the /critical buildings at 30% function/ recovery milestone?

You indicated that /Power/ was on the critical path to one or more of the recovery milestones. Which of the following were on the critical path to restoration of /Power/?

- Restoration of power service
- Repair of generator(s)
- Enough fuel on-site
- Other ________
Recent Progress: Transportation Incident Analysis (1/4)

Transportation Incident Analysis (new project component)
Recent Progress: Transportation Incident Analysis (2/4)

• *Transportation Incident Database* obtained from PR DTOP visit in 2019

• Aim: Process data to answer specific Hurricane Maria Program questions

• Requires mining database, primarily ‘Incident Type’ and ‘Observations’ fields

• Many data processing steps (see below)
Recent Progress: Transportation Incident Analysis (3/4)

Classification of Incidents by Hazard and Impact

- **Landslide**: 800 incidents
- **Inundation**: 100 incidents
- **Scour**: 200 incidents
- **Debris**: 300 incidents
- **Downed power lines**: 400 incidents
- **NA**: 500 incidents
- **Signage**: 600 incidents
- **Debris**: 700 incidents
- **Downed power lines**: 800 incidents
- **Traffic Signal**: 900 incidents

Number of incidents in the infrastructure study area
Recent Progress: Transportation Incident Incident Analysis (4/4)

Classification of Incidents by Hazard and Municipality

- Landslide
- Flooding
- Wind

Municipality: Adjuntas, Aguas Buenas, Aibonito, Bayamón, Caguas, Carolina, Cayey, Ciales, Cidra, Guaynabo, Gurabo, Humacao, Jayuya, Juncos, Lares, Las Piedras, Maunabo, Naguabo, San Juan, San Lorenzo, Toa Baja, Trujillo Alto, Utuado, Yabucoa

Number of Incidents across infrastructure study area

Number of Incidents: 0, 50, 100, 150, 200, 250, 300, 350

PRELIMINARY
Recent Progress: Wireless Communications (1/2)
Recent Progress: Wireless Communications (2/2)

• Conducted initial review of post-storm photo library received from American Tower Corporation
  o Documents post-storm conditions at 131 cell sites
  o Over 6,700 images

• Obtained additional data on cell site infrastructure from the Federal Communications Commission, including
  o Location of additional towers
  o Structure Type, such as
    o freestanding tower, guyed tower, mast, etc.
  o Construction Date
  o Ground Elevation
  o Tower Height
Recent Progress: Integrative Study (1/2)
NIST ARC
An interactive tool for developing alternative sets of actions that meet community resilience and cost goals, given hazard and interdependency information, and socio-economic data.

Beta Version released 9/2020
Project Plan: Next Steps

- Data collection/processing/mining
  - FCC cell site damage
  - American Tower Corp. photo library
  - Geo-database

- Complete pre-pilot draft of interview instrument

- Geospatial analysis

- New version of NIST ARC

- Dependencies

- Transportation Incident Analysis (new sub-project)
  - Geospatial analysis
NWIRP Research Study of Recovery from Hurricane Maria’s Impacts on Puerto Rico

Infrastructure Systems Supporting Critical Buildings and Emergency Communications

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Questions?

Please ‘raise your hand’ using the Blue Jeans Participant window and unmute your audio and video