

UEF-Funded Hurricane Resiliency Workshops

Table of Contents

Section	Slide Number
Executive Summary	3 – 4
Workshop 1	5 – 27
Workshop 2	28 – 55

Executive Summary

Overview

- In the wake of last year's hurricane disasters impacting the lives of many Americans, the media highlighted the need for more preparedness and better adapted infrastructure to mitigate the impact of future catastrophes.
- AIChE received a grant from the United Engineering Foundation (UEF) in January 2018 to support two high-level, multi-disciplinary roadmapping workshops on hurricane disaster relief and resiliency. The objective of these workshops is to convene all of the key engineering professions to develop a roadmap highlighting the key areas, that if addressed through engineering, would improve both our preparedness as well as our recovery from hurricanes.
- The first workshop, which took place in Houston, TX, on March 20–21, 2018, involved participation from many engineering societies. During this workshop, participants identified some of the more immediate needs to optimize, redesign, and complete new resilient infrastructures in the affected areas as well as laid the framework for the overall roadmap.
- The second workshop, which took place in Madison, WI, on July 25–26, 2018, convened members of the broad engineering societies with a particular focus on bringing working engineers together to add more detail to the engineering issues and potential solutions identified during the first workshop.

Workshop 1

Workshop 1

Houston, TX, on March 20–21, 2018

- Face-to-face meeting brought together representatives and members from many of the key engineering professional societies, including AIME, SME, TMS, AIST, SPE, ASME, and IEEE. In addition, industry, academia, and government were all represented at the first workshop.
- Workshop Goals:
 - Develop vision for a desired future state hurricane resiliency and response (roadmap endpoint)
 - Develop list of top issues, learned lessons, and potential engineering solutions (Utility and Communication Infrastructure, Transportation Infrastructure, Industrial Infrastructure, Policy, Environmental Hazards, Other)
 - Create roadmap structure (foundation for second workshop)

Workshop 1

Attendees

Kenneth Arnold, Senior Technical Advisor, WorleyParsons (TMS)

Riad Asfahani, Product Innovations, U.S. Steel (AIST)

Santanu Banerjee, Professor of Physics, Tougaloo College

Kelly Barb, Staff Engineer, PSEG (AIChE)

Sidney Biddle, Corporate Project Engineering Manager, Morgan Corp. (AIChE)

Denise DeLorme, Professor, Dept. of Environmental Sciences, LSU (ASCE)

Marccus Dwayne Hendricks, Professor, Urban Studies and Planning, Univ. of Maryland (Infrastructure Planning & Manag.)

Carmen M. Figueroa-Santiago, Environmental Specialist, EEMES, PSC (Environmental Engineer)

Frank Gibbons, Project Director, Advisian/WorleyParsons (SPE)

Scott Hagen, Professor, Center for Coastal Resiliency, LSU (ASCE)

Dale Hrachovec, Systems Engineer, Adjutant Solutions Group

Shaila Khan, Chair, Dept. of Psychology, Tougaloo College

Meherun Laiju, Chair, Sociology Dept., Tougaloo College

Richard Little, Visiting Scholar, Rensselaer Polytechnic Institute (IEEE)

Roland Moreau, AIME President-Elect (AIME)

Ali Mostafavi, Assistant Professor, Texas A&M Univ. (ASCE)

Abu Obaida Khan, Assistant Professor, Jackson State Univ. (ASCE)

Angela Pakes Ahlman, Assistant Director, Grainger Institute of Engineering, Univ. of Wisconsin-Madison (TMS)

Randall Russell, Chief Systems Engineer, Adjutant Solutions Group (ASME)

Martin Schultz, Environmental Engineer, U.S. Army Engineer Research and Development Center (TMS)

Katherine Touzinsky, Research Scientist, U.S. Army Engineer Research and Development Center (TMS)

William (Al) Wallace, Yamada Corp. Professor, Rensselaer Polytechnic Institute (IEEE)

Workshop 1

Agenda — Day 1/Morning

UEF Hurricane Relief and Resiliency Workshop 1	
Tuesday, March 20, 2018	
7:00am–8:00am	Continental Breakfast
8:00am–8:30am	Opening Remarks and Introductions
8:30am–9:00am	Presentation: What Went Wrong (Hurricanes Harvey, Irma, Maria)?
Roadmapping Infrastructure Resilience	
9:00am–9:30am	Presentation: Review of Infrastructure Rebuild (and Associated Issues) Post-Hurricane Damage
9:30am–9:45am	Break into three small groups—Utility Infrastructure, Transportation Infrastructure, and Industrial Infrastructure
9:45am–10:15am	Small group discussions—Identify main issues that impacted preparedness
10:15am–10:30am	Break and come back to large group
10:30am–11:00am	Report outs from small groups to large group
11:00am–11:30am	Small group discussions—Identify potential solutions for the top 3–5 issues
11:30am–12:00pm	Report outs from small groups to large group
12:00pm–1:00pm	Lunch

Workshop 1

Agenda — Day 1/Afternoon

Roadmapping Disaster Response	
1:00pm–1:30pm	Presentation: Review of Emergency Response and Associated Issues Post Hurricanes
1:30PM	Break into two small groups – Policy Issues, Environmental Hazard Preparedness
1:30pm–2:00pm	Small group discussions – Identify main issues that impacted response to hurricane disasters
2:00pm–2:30pm	Report outs from small groups to large group
2:30pm–2:45pm	Break
2:45pm–3:15pm	Small group discussions – Identify potential solution for the top 3–5 issues
3:15pm–3:45pm	Report outs from small groups to large group
3:45pm–4:00pm	Break
Next Steps	
4:00pm–4:30pm	Large group discussion: Discuss report out from workshop and next steps
4:30pm–5:00pm	List of topics to add to Workshop 2

Workshop 1

Agenda — Day 2

Wednesday, March 21, 2018	
7:00am–8:00am	Continental Breakfast
8:00am–8:30am	Opening Remarks
Roadmapping Immediate Support for Engineers	
8:30am–8:45am	Break into three small groups
8:45am–9:30am	Small group discussions – Identify main issues impacting engineers in affected areas
9:30am–9:45am	Break and come back to large group
9:45am–11:15am	Report outs from small groups to large group
11:15am–12:00pm	Small group discussions – Identify potential solutions for the top 3–5 issues
12:00pm–1:00pm	Lunch
1:00pm–1:30pm	Report outs from small groups to large group
1:30pm–2:30pm	Wrap up – Concluding remarks and next steps

Workshop 1

Small Group Breakout Session-1

- **Groups:**

- Utility and Communication Infrastructure
- Transportation Infrastructure
- Industrial Infrastructure

- **Breakout 1 Questions:**

- What issues did communities/businesses face during and after the major hurricanes?
- What did we do well during and after the major hurricanes?

Workshop 1

Small Group Breakout Session-1

Utility and Communication Infrastructure:

- What issues did communities/businesses face during and after the major hurricanes?:
 - Lack of “pre-thinking” and political-will to do right
 - No Resilience plan for utility systems before the storms
 - Response from people
 - Emergency responders had to take care of their own family first
 - High Stress environments which made the decision making impossible
 - Training for first-responders lacked simulation training
 - Prioritizing improvement areas
 - People do not want something (power plants, generators, etc.) where they need them
 - Existing built environments before were not resilient
 - Water damage (Gas, pipelines, wiring vaults)
 - Wind Damage (Power lines)
 - Evacuation (Hospitals, Infrastructure)
 - Regulation of suppliers
 - Lack of enforced standards for distributive applications
 - Local utilities overburdened (Mutual Aid, Lodging costs)
 - Coordination of aid efforts (Government organizations, non-profits)

Workshop 1

Small Group Breakout Session-1

Transportation Infrastructure:

- What issues did communities/businesses face during and after the major hurricanes?:
 - Roads were blocked and damaged
 - Distribution networks were offline, which caused materials, communications, supplies to be limited
 - Storm water run-off, drainage was not effective, vehicles stuck on roads
 - Drivers to deliver goods and services were not available
 - Operable evacuation routes were very limited, side roads were damaged, communications limited
 - Getting the main ports back up and running docks were not clear, which made it hard to bring things in and out of the area
 - Materials movement: Coordination and movement of goods to restore power, etc.
 - Swift water mapping and vulnerability, knowing who has the ability to evacuate
 - Possibly invest in low cost sensors to monitor water
 - Help coordinate availability and distribution of fuel
 - Real time mapping and communications

Workshop 1

Small Group Breakout Session-1

Transportation Infrastructure:

- What did we do well?:
 - Recognizing opportunities for pipe lines
 - Cajun Navy, Texas Task force
 - In Houston, the medical response teams were prepared
 - Developed relationships ahead of time, and cleared streets with pumping stations
 - In Key West, FL, a main bridge was brought back up to speed very quickly

Workshop 1

Small Group Breakout Session-1

Industrial Infrastructure:

- What issues did communities/businesses face during and after the major hurricanes?:
 - Puerto Rico: Industrial Infrastructure is private
 - Different economic drivers
 - Different regulations
 - Individual Data: Not distributing or allowing access
 - Houston:
 - No planning for worst-case scenarios of industrial plants
 - No cost-benefit analysis on incidents/scenarios
 - Companies do not rake on the role of providing services for surrounding areas
 - Not knowledgeable of how an industrial plant will run during a disaster
 - Relationship of public infrastructure not established
 - Lack of planning and understanding of how the impact of oil and gas refineries shutting down will affect the rest of the country
 - Strategic petroleum reserve was not replenished and available
 - Companies are not investing in resiliency, and maintaining equipment
 - There is a lack of balanced regulation
 - Supply Chain issues

Workshop 1

Small Group Breakout Session-2

- **Groups:**

- Utility and Communication Infrastructure
- Transportation Infrastructure
- Industrial Infrastructure

- **Breakout 2 Questions:**

- What are potential solutions to address top 3–5 issues identified in first small group?

Workshop 1

Small Group Breakout Session-2

Utility and Communication Infrastructure:

- What are potential solutions to address top 3–5 issues identified in first small group?:
 - Should have first responders down to facility level
 - All Societies should work together and coordinate development of an API recommended practice on having first responders for resiliency
 - IEEE and NFPA develop recommended practices for building resiliency into substations & power plants
 - UEF to develop programs to distribute and promote standards
 - ASCE to promote resilient design for residencies
 - Education
 - UEF to ask ABET to include resilient design where appropriate when evaluating engineering programs
 - Resilient Design Topical at Conferences, workshops, and in publications
 - After Action Review to evaluate if resilient concepts would have helped

Workshop 1

Small Group Breakout Session-2

Transportation Infrastructure:

- What are potential solutions to address top 3–5 issues identified in first small group?:
 - Utilize mathematics and modeling to look at current factors
 - Such as: How many people can we evacuate?
 - One model for each major city impacted, updated on an annual basis
 - Transdisciplinary approaches to complex issues
 - Scholarly
 - Stakeholders
 - Current Distribution options for different scenarios
 - Computational Modeling: Utilize Universities
 - Quantify how the models fit, get rid of uncertainty
 - Have funded research that includes a risk description
 - Monitoring water flow, information in real time
 - Traffic management systems displayed during disasters, and normal flash floods

Workshop 1

Small Group Breakout Session-2

Industrial Infrastructure:

- What are potential solutions to address top 3–5 issues identified in first small group?:
 - Public funding for flood insurance
 - Demonstrate value of planning/preparedness so leadership boards have a case for investment
 - Smart regulation for leadership boards to address resistance of the small investment to prepare
 - Private insurers could be incentivized to offer discounts to companies
 - Available computer simulations of various scenarios
 - 3D graphics to show relationship
 - Identify probability of component damage, the impact of that damage, and to prioritize the actions
 - Need analytical tools and resources available for SMEs to develop risk-based simulations and analysis
 - Paradigm shift in how flood risk is evaluated to move away from flood insurance program
 - Industrial Companies: Whether or not a company has incentive to invest in planning depends on the circumstances of the company – Cause of lack of investment

Workshop 1

Small Group Breakout Session-3

- **Groups:**

- Policy Issues
- Environmental Hazard Preparedness
- Other

- **Breakout 3 Questions:**

- What issues did communities/businesses face after the major hurricanes?
- What did we do well after the major hurricanes?

Workshop 1

Small Group Breakout Session-3

Policy Issues

- What issues did communities/businesses face after the major hurricanes?:
 - Industrial Involvement
 - Communication
 - Public-Private collaboration (503C)
 - Private- public collaboration (Private funding, incentive, etc)
 - Develop an App for phones/tablets (technical solutions)
 - Local Government, Industry leaders, community involvement
 - Early and on-going involvement
 - Identify and leverage resources that exist
 - Grant: Modules and simulations of evacuation plans (visual)
 - For Ex: build into video games including visual aspects
 - Identify Committees
 - Data that tackles uncertainty: How nature will behave, and storm frequency
 - Pulling university work together
 - Justifications for rebuilding, etc.
 - Verify this data for quantification
 - Gather projections of storms (Model)
 - Figure out what we can measure or not measure
 - Reduce the "Ripple Effect" on the economy
 - Need to get government leaders such as junior senators to see the validity and good faith of a cost analysis that is prepared (LCA, LCCA). You also need CBO, GAO to agree with what you are proving, and have the senator representatives back you up.

Workshop 1

Small Group Breakout Session-3

Environmental Hazard Preparedness

- What issues did communities/businesses face after the major hurricanes?:
 - Debris
 - Any survivors?
 - Where will it be relocated?
 - How do you clear it?
 - Clearing access (e.g., roads)
 - Wires
 - Downed live wires.
 - Are they alive?
 - Industrial facilities/Hazardous Materials
 - Chemical discharge
 - Secondary Health Effects (long term)
 - Sewage Plants (flooding)
 - Storm Drains
 - Overflow
 - Can go into sewage system in older systems
 - Equity issue
 - Fires
 - Spreading of flammable chemicals
 - Ruptured gas pipe lines
 - Mudslides
 - Stray Animals
 - Lawlessness/Looting
 - Desperation
 - Social issues
 - Circumstance
 - Broken pipe Lines
 - Gas, Hydrocarbon, oil
 - Broken water sewage lines create contamination
 - Loss of pressure/power → leads to contamination
 - Subway/underpasses/road tunnels
 - Loss of fuel
 - Loss of transportation

Workshop 1

Small Group Breakout Session-3

Other Issues (Communication, Education, etc)

- What issues did communities/businesses face after the major hurricanes?:
 - Lack of communication platform to communicate with the community and responders (No phone service, no internet)
 - Lack of training for worst-case scenarios
 - No accepted structure around communications chain of command
 - Cultural issues that cause may prevent people from evacuating

Workshop 1

Small Group Breakout Session-4

- **Groups:**

- Policy Issues
- Environmental Hazard Preparedness
- Other

- **Breakout 4 Questions:**

- What are potential solutions to address top 3–5 issues identified in first small group?

Workshop 1

Small Group Breakout Session-4

Policy Issues

- What are potential solutions to address top 3–5 issues identified in first small group?:

Workshop 1

Small Group Breakout Session-4

Environmental Hazard Preparedness

- What are potential solutions to address top 3–5 issues identified in first small group?:
 - Lawlessness
 - National Guard can help keep law and order
 - Preplan first responders for immediate emergency response
 - Have first responders down to facility level
 - AIChE works with other societies to coordinate development of an API recommended practice on having first responders for resiliency
 - IEE and NFPA develop recommended practices for building resiliency into substations & power plants
 - UEF to develop programs to distribute and promote standards
 - ASCE to promote resilient design for residencies
 - Education
 - UEF to ask ABET to include resilient design where appropriate when evaluating engineering programs
 - Resilient Design Topical at Conferences, workshops, and in publications
 - After Action Review to evaluate if resilient concepts would have helped
 - Engineering societies to promote concept of building in resiliency to pre-built/established environments as part of new projects

Workshop 1

Small Group Breakout Session-4

Other (Communication, Education, Etc.)

- What are potential solutions to address top 3–5 issues identified in first small group?:
 - Lack of Organization around communication, Chain of command
 - One voice to oversee all organizations so everyone knows who is in charge (Puerto Rico)
 - To communicate between authorities and community; communicate one message
 - Have a system in place to identify how all of the Emer Res teams work together
 - Do drills with the different emergency response organizations, working together in response to a hurricane.
 - When having drills, have a different operation. Look at how the team responds to surprise and practice operating under a different leadership.
 - Have an organized “Cajun Navy”
 - Develop a system that raises volunteer organization to respond and direct action
 - Need a way to communicate with, and direct this group
 - Contact churches, Ag. Co-ops, to organize into a group
 - Have a volunteer contact person on emergency response team
 - Education/Training
 - Run drills on a regular basis and enforce them
 - When residents choose not to leave
 - Unable to solve cultural issues
 - When residents cannot leave
 - Have a plan for people with physical challenges and those with economic challenges

Workshop 2

Workshop 2

Madison, WI, on July 25–26, 2018

- Face-to-face meeting brought together engineers and scientists working in areas of infrastructure resiliency, hurricane preparedness, modeling, and other related fields.
- Workshop Goals:
 - Fill in the roadmap pieces by prioritizing and fleshing out gaps and solutions identified in the first workshop
 - Identify any missing pieces that were overlooked in the first workshop

Workshop 2

Attendees

Thomas Seager, Arizona State University (Civil Engineer)

Baabak Ashuri, Georgia Institute of Technology (Industrial and Systems Engineer)

Nasim Uddin, University of Alabama (Civil and Environmental Engineer)

Hanna Rodriguez, IEMES, PSC | SWANA | CIAPR (Environmental Engineer)

Edgar Hernandez, AIChE, Puerto Rico Local Chapter (Chemical Engineer)

John van de Lindt, Colorado State University (Civil Engineer)

Andrew Graettinger, University of Alabama (Geotechnical Engineer)

Ruth L. Trujillo, Professional Land Surveyor & Professional Planner (Land Surveyor)

Rodrigo Castillo Perez, University of Florida (Civil Engineer)

Michele Barbato, University of California Davis (Environmental Engineer)

Mohsen Shahandashti, University of Texas (Civil Engineer)

Thomas Haase, Sam Houston State University (Political Science)

Workshop 2

Agenda — Day 1/Morning

Wednesday, July 25, 2018	
8:00am–9:00am	Morning Refreshments
9:00am–9:30am	Opening Remarks and Introductions
9:30am–10:00am	Present Roadmap developed from Workshop 1
Roadmapping Utility Resilience	
10:00am–10:10am	Roadmap gaps for Utility Resiliency
10:10am–10:30am	A case study in wind hazard mitigation by Rodrigo Castillo Perez, University of Florida
	Break into Small Groups: Water, Electricity, Communications Infrastructure
10:30am–11:30am	Small Group Discussion: <ul style="list-style-type: none"> – Review, Refine, and Rank Gaps – Brainstorm Pathways for Top 3 Gaps
11:30am–12:00pm	Report outs: Slides with Top 3 Gaps and Potential Pathways
12:00pm–1:00pm	Lunch

?

Workshop 2

Agenda — Day 1/Afternoon

Roadmapping Critical Infrastructure Response	
1:00pm–1:10pm	Roadmap Gaps for Transportation and Industrial Infrastructure
1:10pm–1:35pm	Predicting Wind Hurricane Hazard under Changing Climate Conditions, by Michele Barbato, University of California Davis
1:35pm–2:00pm	Puerto Rico after Hurricanes Irma and Maria, by Hanna Rodriguez, EMES,
	Break into Small Groups: Transportation and Industrial Infrastructure
2:00pm–3:00pm	Small Group Discussion: – Review, Refine, and Rank Gaps – Brainstorm Pathways for Top 3 Gaps
3:00pm–3:30pm	Report Outs: Slides with Top 3 Gaps and Potential Pathways
3:30pm–3:45pm	Break

?

Workshop 2

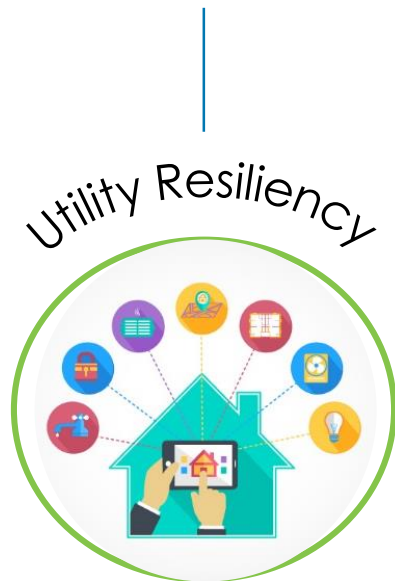
Agenda — Day 1/Afternoon Agenda Contd.

Roadmapping Modeling & Simulation	
3:45pm–4:10pm	Geospatial Data Mining and Analysis, by Ruth Trujillo, Professional Land Surveyor
4:10pm–4:35pm	Modeling Building Loads, by John Van der Lindt, Colorado State University
4:35pm–5:00pm	Modeling and Policy, by Baabak Ashuri, Georgia Institute of Technology
5:00pm–5:30pm	<p>Large Group Discussion:</p> <ul style="list-style-type: none"> – Brainstorm individually: Identify three data-enabling purposes (What do we need from data and models to help with the gaps/pathways identified in the first two sessions?) – What type of data is needed for each objective? – What data/modeling already exists? – What data/modeling is needed to close the gap?

Workshop 2

Agenda — Day 2

Thursday, July 26, 2018	
7:00am–8:00am	Morning Refreshments
8:00am–8:15am	Report Outs from Day 1
Roadmapping Modeling & Simulation (contd.)	
8:15am–8:45am	<p>Large Group Discussion:</p> <ul style="list-style-type: none"> – Brainstorm individually: Identify three data-enabling purposes (What do we need from data and models to help with the gaps/pathways identified in the first two sessions?) – What type of data is needed for each objective? – What data/modeling already exists? – What data/modeling is needed to close the gap?
Roadmapping Research and Technology Development for Hurricane Resiliency	
8:45am–8:50am	Present the three areas within this arm of the roadmap
8:50am–9:20am	Research and Technology by Andy Graettinger, University of Alabama
9:20am–10:15am	Break into small groups: Adaptive Designs, Integrated Engineering, Sensors and Automation
	Small Group Discussion: If you were a project team given the task of developing a program to address this R&D need for your company, what would you do?
10:15am–10:30am	Break
10:30am–11:00am	Report Outs: Each group gives 15 min presentation
Wrap Up	
11:00am–11:30am	Wrap up workshop – Next steps (what to expect) and Pluses/Deltas



- **Water/ Wastewater System**

- Addressing built infrastructure when it reaches its limits
- Sewage infrastructure damage
- Ability of wastewater treatment facilities to provide clean drinking water during/after storms

- **Electrical Grid/ Power**

- Above-ground power lines not built for high winds experienced during 2017 hurricanes
- Long recovery time for power to get back up and running
- Utilities struggle to balance between over- and under-preparation because of a lack of methods for rigorously estimating impacts of hurricanes

- **Communication Systems**

- Lack of organization around communication, chain of command
- Lack of robust system for first responders
- Lack of formal communication network to communicate in real time with public

Workshop 2

Small Group Breakout Session-1

- **Groups:**
 - Water Infrastructure
 - Electrical Infrastructure
 - Communications Infrastructure

- **Breakout 1 Questions:**
 - Review, Refine, and Rank Gaps
 - Brainstorm Pathways for Top 3 Gaps

Workshop 2

Small Group Breakout Session-1

Water Infrastructure Gaps:

Water Infrastructure

- During hurricanes, there is a risk of water-borne diseases
- Centralized water treatment facilities get flooded
- Sewage infrastructure damage
- Lack of redundancy in power and water
- Ability of wastewater treatment facilities to provide clean drinking water during/after storms
- Sewage infrastructure damage

Workshop 2

Small Group Breakout Session-1

Water Infrastructure Pathways:

- Centralized water treatment facilities get flooded and no longer protect water systems:
 - Elevated water heaters for providing homes 30-60 gallons of water (decentralized solution – in case centralized system goes down). Right now water heaters are in basements but it would be hard to collect water in a bowl from the bottom of the heater.
 - Create a new code to move water heaters (specifically in the north east)
 - Design codes (centralized solution) with a better model and technical solution for water systems (General – for all utilities)
- Centralized and non-centralized
 - Explore better models and technical solutions beyond centralized systems (emory case/tech)
 - Advanced sensing, monitoring, diagnostic, and inspection tools for recovery and better preparation
 - Models must keep up and adapt to the changing, dynamic demand (population growth, and climate change)

Workshop 2

Small Group Breakout Session-1

Communication Infrastructure Gaps:

- People need credible information to make decisions during disaster and people need to coordinate decision making
- Cell phone towers have a bandwidth and during disasters they are exceeded and communication systems are damaged (no cell, no wifi)
- Lack of organization around communication, chain of command
- Lack of robust system for first responders
- Lack of formal communication network to communicate in real time with public
- Backup communication systems and infrastructure are destroyed but not repaired/replaced
- Technology available now may not be enough to address the emergency

Workshop 2

Small Group Breakout Session-1

Communication Infrastructure Pathways:

- Work with cell providers to enable more roaming options
- Alternative communication modes that work post-disaster
 - Peer-to-peer mesh networking (e.g., my phone's Bluetooth can connect to someone else's cell phone) – Get rid of wifi, use something more robust like bluetooth
 - Use satellite wifi systems, move away from terrestrial
 - Citizens band radio
 - Drone based ad-hoc network (temporary wifi system)
- Very few data and predictive information (on extent of the problem) on damage to communication infrastructure such as cell towers (electrical systems do not have fragility data)
- Who pays for all of this? -> No incentive for private companies

Workshop 2

Small Group Breakout Session-1

Power Infrastructure Gaps:

- Problem with electrical grid system: Centralized system that is built mainly above ground
- Above-ground power lines not built for high winds experienced during 2011 hurricanes
- Long recovery time for power to get back up and running
- Utilities struggle to balance between over- and under-preparation
- Geo-spatial challenges
- Funding issues to build underground system

Workshop 2

Small Group Breakout Session-1

Power Infrastructure Pathways:

- Change policy to enable decentralized power
- Advanced, cost-effective technologies to improve transmission lines

Critical Infrastructure — Gaps



- **Transportation**

- Real-time maps of the roads and transportation systems is not available
- Getting the main ports back up and running is difficult, which makes it hard to bring things in and out of the area
- Roads not built for wind/flooding from hurricanes and they get damaged and blocked

- **Industrial**

- No planning for worst-case scenarios of industrial plants
- Lack of planning and understanding of how the impact of oil and gas refineries shutting down will have on the rest of the country
- Companies are not investing in resiliency, and maintaining equipment

- **Residential**

- Lack of available shelter for those displaced by storms
- Lack of coordinated evacuation plans
- Zoning regulations that prevent people from building in areas that could be impacted by extreme events or require flood proofing

Workshop 2

Small Group Breakout Session-2

- **Groups:**
 - Transportation Infrastructure
 - Industrial Infrastructure
 - Residential Infrastructure

- **Breakout 1 Questions:**
 - Review, Refine, and Rank Gaps
 - Brainstorm Pathways for Top 3 Gaps

Workshop 2

Small Group Breakout Session-2

Transportation Infrastructure Gaps:

- Ensuring capability of re-allocating resources under condition of high stress via our transportation systems
- Inter-agency logistics
- Limited resources available but are necessary for day-to-day operations
- Prioritizing allocation of resources
- Lack of upkeep to ensure proper condition of roads
- Quicker return to road functionality

Workshop 2

Small Group Breakout Session-2

Transportation Infrastructure Pathways:

- Determine what transportation assets we have and the condition of them
- Above-ground transportation Solutions:
 - New, stronger materials
 - Pervious concrete
 - Adaptive designs of roads and bridges
- Below-ground solutions
- Emphasize and influence the use of public transportation
- Coordinated allocation of resources
- Policy for coordinated transportation agencies to work together
- Develop recovery strategies – developed based on characteristics of the system, different for different cities (NYC, Houston)
- Effective recovery procedures that are compatible with local transportation systems (Ex. Evacuation)
- Traffic monitoring and traffic management (*Soft Infrastructure)
- Impact of autonomous vehicles

Workshop 2

Small Group Breakout Session-2

Industrial Infrastructure Gaps:

- Business continuity
- Health and Safety
- Businesses shut down, can't get materials in and out, businesses cannot operate normally which effects the health and safety of the people
- Integrating risk management
- Communities severely affected by shutdown of large companies (e.g., pharma)
- Shifting focus away from short-term profit
- Systems integration

Workshop 2

Small Group Breakout Session-2

Industrial Infrastructure Pathways:

- Interaction between transportation and supply chain need interdependence. This interdependence should be studied, modeled, and understood in order to predict a better interaction (pipeline, roads)
- Plan for catastrophic event than will not shut down the plant for good
- Share the risk between businesses and the public
- Spatial location (regionalization such as industrial parks)

Workshop 2

Small Group Breakout Session-2

Residential Infrastructure Gaps:

- Problem: Residential homes are damaged from hurricanes, which creates a cascade effect because these people run the transportation system, fire department, hospitals, etc.
- Amount of damage or resiliency of homes is not equal -> resiliency/affordability/equity
- The vulnerable (aging) population, prisoners, illegal immigrants disproportionately suffer
- Lack of community shelters
- Need for better building code enforcement and communicating what is in the codes
- Lack of information on insurance claims
- Use of insurance to change behavior

Workshop 2

Small Group Breakout Session-2

Residential Infrastructure Pathways:

- New, cost-effective home design/technology
 - Modular infrastructures that can be easily restored (new cost effective home designs)
- Retrofitting existing homes
 - Risk communication with public
 - These technologies exist and are easy to install
 - Understand misconceptions and misbeliefs of communities will improve communication
 - Complex policy is a barrier between home owners and certain government funded opportunities to receive funding and help to make their home resilient
 - They have to apply and comply
- Need sufficient temporary shelters, and emergency shelters
- Enforce a policy that will push people out if it is not safe for them to be there (e.g., use incentives)

Modeling and Simulation

Large Group Discussion

- Brainstorm individually: Identify three data-enabling purposes
- What do we need from data and models to help with the gaps/pathways identified in the first two sessions?

Workshop 2

Small Group Breakout Session-3

- **Groups:**

- Modeling and Simulation-1
- Modeling and Simulation-2
- Modeling and Simulation-3

- **Breakout 3 Questions:**

- What type of data is needed for each objective?
- What data/modeling already exists?
- What data/modeling is needed to close the gap?

“When Hurricane Harvey made landfall on the gulf coast of Texas in late August, it led to widespread flooding in Houston and other cities and towns. In some places more than 15 inches of rain fell in a 24-hour period, quickly inundating roads, highways and entire neighborhoods. Damage from the storm is expected to be in the billions of dollars.

Then, even as commentators and onlookers invoked the word “historic” for Harvey in one breath, the very next breath was given to the historic proportions of Hurricane Irma, relegating coverage of Harvey to a backseat as one of the largest hurricanes recorded took aim at Florida.

As these areas work to recover, we face a compelling question: Given that weather extremes are expected to become even more severe and frequent, how can and should efforts to replace lost and damaged infrastructure aim to make it better able to withstand disastrous events to come?”





- **Adaptive Designs**
 - Using predictive models to create adaptive and resilient infrastructure
- **Sensors and Automation**
 - Self-sustained technologies that can adapt to environmental alterations and relay real-time data
- **Integrated Engineering**
 - Continuous implementation of new engineering principles and information to designs

Workshop 2

Small Group Breakout Session-4

- **Groups:**

- Adaptive Designs
- Integrated Engineering
- Sensors and Automation

- **Breakout 4 Questions:**

- Pretend you are a project team tasked with developing a program to address this RD&D need for your company.
 - What would you do?
 - Start formulating a plan
- Formulate problem, identify resources needed, develop plan of action