Port Resilience R&D: using available resources for building better projects

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AAPA HARBORS & NAVIGATION COMMITTEE AND QPI MEETING
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Resilience is a term that encompasses four general concepts: **Prepare, Resist, Recover, and Adapt**. These four concepts allow for flexibility in application across USACE business lines and project scales.

This loose definition can be a problem when applying these concepts to management or decisions. Assessment can be largely subjective and applied with varied meanings.
Resilience to multiple hazards

As-New Performance

Expected loss in function over time

London Ave Canal, New Orleans LA

Nuisance flooding, Hampton Roads VA

Marsh Loss, Chandeleur Islands LA
Resilience Over Time

Rebuilding, new projects, community awareness, etc.

Prepare; Anticipate

Disturbance

Adapt; Evolve

Resist; Withstand

Recover Bounce Back

Resilience increased:
- Less loss in functionality
- Faster recovery time
Research Challenges

• RESILIENCE = call to action!
• SYSTEM-wide understanding is elusive

Need #1 - Assessment can be largely subjective and the definition of resilience is applied with variable meaning

Need #2 - A need exists for the development of objective tools and applications that Districts (& others) can use to quantify coastal system resilience.

FY19 Appropriations Act resulted in $292.7M for the Port Infrastructure Development Program to improve port facilities at coastal ports

Five Outcome Criteria:
1. advance technology-supported safety and design efficiency improvements;
2. bring facilities to a state of good repair and improve resiliency
3. promote efficient trade in energy resources
4. promote exports of manufacturing, agriculture, or other goods; and
5. Support the safe flow of agricultural and food products, free of pests and disease, domestically and internationally. Accordingly, the Department
Research Approach

Need #1 – Assessment can be largely subjective and applied with varied meanings

- Develop assessment methodologies for understanding resilience

1. Conduct an inventory of available methodologies and outstanding needs
2. Apply resilience definition to ID potential indices and metrics across different scales of analysis
3. Highlight outstanding needs for future research

Twelve research projects were funded through the CSR Research Initiative.
ID Assessment Methods

Review Resources & Literature

- Channel Portfolio Tool utilizing Waterborne Commerce Data
- Automatic Identification System Analysis Package utilizing USCG National AIS Database

AIS data to observe regional patterns in vessel traffic
Waterborne Commerce Data
to understand major commodity flows, connectivity and timing
Travel Time Atlas for inland river systems

- Provides historical and near real-time waterway transit times between origins and destinations
- Publically accessible
- Example Applications:
  - Voyage planning
  - River Information Services
  - Multi-modal connectivity
  - Traffic monitoring

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Regional Navigation Traffic During Disruptions

Hurricane Harvey Cargo and Tanker Vessel Signal Density Plots

- August 1, 2017: Tropical Storm Harvey will be named August 15
- August 24, 2017: USCG declares Port of Houston under condition Yankee
- August 25, 2017: USCG declares Port of Houston under condition Zulu
- August 26, 2017: Hurricane Harvey makes landfall at Rockport & becomes a tropical storm over inland Texas
- August 28, 2017: Harvey recedes towards the Gulf, record rainfall recorded at 51.68 in
- September 4, 2017: Vessels queue at anchorage areas. Port reopens with restrictions September 16

ERDC Navigation Data Performance Team: Katherine Touzinsky, Kenneth N. Mitchell, Patricia Djoseph, Marvin Kress
Port Resilience Indices

- Understand baseline function of our navigation systems and the impacts of disruptions
- Evaluate and monitor project performance in real-time
Visualize inter-port flows and connectivity
Understand disruption impacts to networks

Page Ranked Network Analysis during Hurricane Harvey

- Calcasieu
- CorpusChristi-PortAransas
- MatagordaPortLavacaComfort
- Pascagoula
- PortArthur
- PortBeaumont
- PortEverglades
- PortFreeport
- PortGalveston
- PortHouston
- PortTexasCity
- PortVictoria
- PortofMiami
- PortofTampa
- SouthwestPass
Resilience Resource Overload!

Starting Materials (Chemicals, Cultures, & Tissues)

- Synthesis
- Extraction
- Drying and Comminution
- Fermentation
- Dilution in Liquid Excipients
- Mixing with Powdered Excipients
- Syrups, Drops, & Phials
- Ointments & Suppositories
- Granulation or Milling
- Lyophilization (Freeze-Dried Products)
- Capsule, Granules, Tablets, & Pills

Direct Use (Antibiotics in powder form, etc.)

Compression & Cleaning

Packaging

Proportioning

Active Pharmaceutical Ingredient

Labeling

Consumer Product

Pharmaceutical Product

Quality Control (Internal and/or External)

Quality Control (Internal and/or External)

Distribution

Substation Distribution Control Center

Transmission Substation Transmission Control Center

Generating Plant

Maritime Transportation

Road Transportation

Information Technology

Communications

Water Wastewater

Oil and Natural Gas Subsector

Assessing Interdependencies

Hazard & Impact Modeling and Simulation

Analyzing Supply Chain Risks
Research Approach

Need #2 – A disparity exists between published resources on resilience and usable/accessible information for decision support and project planning.

→ Create user-driven resources for approaching resilience across different systems

→ DHS & ERDC– Joint Agency Port Resilience Assessment Guide
  1. How can the existing body of knowledge on port and maritime resilience be integrated and expanded to create a holistic guide for assessing and improving the resilience of the MTS?
  2. Gain insight on key issues and user objectives of stakeholders who work on the system
  3. Develop a user-friendly Guides to resources for assessing the resilience of complicated infrastructure (grey and green) systems
<table>
<thead>
<tr>
<th>Resource Name</th>
<th>Scope</th>
<th>Assessment Tier</th>
<th>Resource Type</th>
<th>Resilience Phases</th>
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<tr>
<td>Self Assessment - Improving Freight Transportation Resilience in Freight Analysis Framework (FAF)</td>
<td>MTS Network</td>
<td>1</td>
<td>Methodology</td>
<td>Prepare, Absorb, Recover, Adapt</td>
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<tr>
<td>Freight Fluidity Study</td>
<td>MTS Network</td>
<td>3</td>
<td>Data Source</td>
<td>Prepare</td>
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<tr>
<td>State of Hawaii Navigation Information System</td>
<td>MTS Network</td>
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<td>Prepare</td>
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<tr>
<td>Resilience Matrix (Linkov 2015)</td>
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<td>Tool</td>
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<tr>
<td>Port Resilience Index</td>
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<td>2</td>
<td>Methodology; Academic</td>
<td>Prepare, Adapt</td>
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<tr>
<td>INRIX City Guide</td>
<td>Single port</td>
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<td>Tool</td>
<td>Prepare</td>
</tr>
<tr>
<td>National Performance Management Research Data (NPMRDS)</td>
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<td>Bayesian Network Analysis</td>
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<td>ADCIRC model</td>
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<td>Functional Resonance Analysis Method (FRAM; Hollnagel 2015)</td>
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<td>Agent-based models</td>
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<td>Multicriteria Decision Analysis (MCDA)</td>
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<td>Disaster Resilience Indicators for Benchmarking Baseline Conditions</td>
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<td>Water Resource Information System (WRIS) Portal</td>
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<td>Social Vulnerability Index for Disaster Management (SOVI; Flanagan)</td>
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<td>Disaster Resilience Scorecards (Sands 2015; Williams et al. 2014)</td>
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<td>Marine Cadastre</td>
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<td>Rapid Assessment of Hurricane Damage and Disruption to Interdependencies</td>
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<td>Assessment and Measurement of Port Disruptions Project (Gabe)</td>
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<td>Community Resilience Planning Guide for Buildings and Infrastructure</td>
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<td>Method to Measure Climate and Extreme Weather Variability to Infrastructures (EDGes)</td>
<td>Single port</td>
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<td>Cyber-physical Disruption, Mitigation, and Response Catalog (Gabe)</td>
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<td>COTP Zone Area MTS Recovery Plan Guidelines</td>
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<td>Common Access and Reporting Tool (CART)</td>
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<td>Predictive Port Resilience Tool to Assess Regional Impact of Hurricane</td>
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Assessment Method Selection - Tiered Framework

**TIER 1**
- Seek to understand and prioritize the critical functions of the system
  - Outcomes: quickly IDs critical functions, key sectors, and any easy wins. If more information is needed to control for resilience identifies info necessary for Tier 2.

**TIER 2**
- ID structure of the system including cascading events during disruption by utilizing both experts and observational data
  - Outcomes: reveal structure of system and interrelated components to be able to compare project or investments.

**TIER 3**
- Analyze the system’s key functions and structure throughout disruptions and drops in function.
  - Outcomes: qualitative metrics and understanding of the recovery process in order to ID intervention opportunities and management plans.

Increasing cost and information

Proceed through tiers until there is adequate information for decision making.
<table>
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<tr>
<th>Navigation Resources</th>
<th>Single Port</th>
<th>MTS Port Network</th>
<th>Inland Waterway</th>
</tr>
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</table>
| **Tier 3**           | - Bayesian Network Analysis (Schultz et al 2016)  
- Assessment and Measurement of Port Disruption (Weaver 2019) | Outstanding Need for methodologies! | - Bayesian Kernel Critical Infrastructure Analysis of L&D (Baroud 2014) |
| **Tier 2**           | - Scenario-based exercise with expert elicitation (many examples) | - PORT MAPPER (Trepte and Kai 2014)  
- Multiple Port Vulnerability Indicators Methodology (Becker 2018)  
- Regional Resilience Toolkit | - Collaborative Modeling to Support Adaptive and Resilient Water Resource Governance in the Inland Northwest (King and Thorton 2016) |
| **Tier 1**           | - Port Resilience Index (NOAA 2016)  
- MTS Recovery Plan Guidelines (USCG 2018) | - Supply chain resilience planning  
- Dredge Optimization Scheduler (USACE 2018) | - Improving Freight Transportation Resilience in Response to Supply Chain Disruptions (NCRFP 2019) |
Essential Elements of a Resilience Framework

1) ENGAGE – Lay the Foundation
   - Form a collaborative team with leader, team members, key stakeholders
   - Understand the situation/system and interdependencies

2) ASSESS – Conduct a Resilience Assessment
   - Define goals and objectives of effort (long term performance vs expected performance)
   - Select a methodology according to the goals and system

3) ACT – ID and Prioritize Strategies and Decisions
   - Evaluate costs, benefits, and value of each action
   - Create a stepwise plan

4) FUND – Fund for Action
   - Resilience Dividend – enable better withstand and recover from disruptions AND improves normal operations by lessening chronic stressors

5) MEASURE – Evaluate Results and Refine Methods
   - Revisit actions to see if they are improving the system
## Combining Assessments and Resources with Existing Frameworks

<table>
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<th>Tier 3</th>
<th>Tier 2</th>
<th>Tier 1</th>
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<td>MTS Port Network Analysis</td>
<td>Scenario-based Workshop / Assessment</td>
<td>FEMA Local Mitigation Planning Framework</td>
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<td>NOAA Port Resilience Index</td>
<td>MTS Recovery Unit Plan</td>
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### Additional Guidance and Resources

- **Tier 3**
  - Guidance for stakeholder assembly, prioritizing needs and objectives
  - Guidance on critical functions and infrastructure interdependency
  - Guidance for integrating risk into resilience solutions
  - Guidance on stakeholder engagement, regulations & statutes
  - Guidance on implementing results, including funding

- **Tier 2**
  - Guidance for stakeholder engagement, regulations & statutes

- **Tier 1**
  - Guidance on implementing results, including funding
Future Work

- Learning and data availability is enhanced through collaborations (organizations, academics, government, etc.) (McLean and Becker 2019)
- Need more understanding of adaptation (adaptive capacity) between disruptions
- “Hybrid” approaches is often cited to provide optimal benefits for the resilience of the entire system; need formal understanding
- More research is warranted to draw connections between resilience concepts and inland waterway processes (Echevarria-Doyle and Chambers 2019)
Questions?

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