2017 Resiliency Peer Exchange
On Extreme Weather and Climate Impacts

Washington DC
November 6-7, 2017

Dave Fletcher
GPC, Inc.
The Case for Resiliency to Extreme Weather Events

A Nationwide Concern

An Economic Imperative

A Leadership Requirement
Understanding Transportation Resilience


Fundamental Capabilities of Effective All Hazards Infrastructure Protection Resilience, and Emergency Management for State Dots (2015)


What is resilience?

The ability to prepare and plan for, absorb, recover from, or more successfully adapt to adverse events.

AASHTO
Resilience has many faces,
...many dimensions,

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Emergency Management</th>
<th>Design Engineering</th>
<th>Climate, Community and Societal Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission</td>
<td>Prepare, Respond, Recover</td>
<td>Resist, Adapt</td>
<td>Plan, Resist, Adapt, Relocate</td>
</tr>
<tr>
<td>Duration</td>
<td>Hours - Months</td>
<td>Years - Decades</td>
<td>Decades or longer</td>
</tr>
<tr>
<td>Potential Disruptions</td>
<td>Extreme weather events</td>
<td>New loading &amp; durability</td>
<td>Climate change impacts</td>
</tr>
<tr>
<td></td>
<td>Natural disasters</td>
<td>requirements</td>
<td>Sea level rise</td>
</tr>
<tr>
<td></td>
<td>Terrorist incidents</td>
<td></td>
<td>Mass migrations</td>
</tr>
<tr>
<td>Impact</td>
<td>Local - Regional</td>
<td>Local</td>
<td>Superregional - Global</td>
</tr>
<tr>
<td>Governance</td>
<td>Varies but Public Safety Agencies (PSA)</td>
<td>Varies but State DOTs generally</td>
<td>All levels of government</td>
</tr>
<tr>
<td></td>
<td>generally provide</td>
<td>provide Project Management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incident Command</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation Agency Role</td>
<td>Support evacuation and emergency access</td>
<td>Engineering and construction</td>
<td>Funding Planning</td>
</tr>
<tr>
<td></td>
<td>activities</td>
<td>services</td>
<td>Policies and Standards</td>
</tr>
</tbody>
</table>

November 2017
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... many scales,
...and many choices
## AASHTO 2016-2018 Resilience Research Program

<table>
<thead>
<tr>
<th>20-59(54)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 3 Discussion Papers</td>
</tr>
<tr>
<td>- 2020-2025 Resilience Research Roadmap</td>
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<tr>
<td>- CEO Interviews</td>
</tr>
<tr>
<td>- CEO Forums</td>
</tr>
<tr>
<td>- CEO Primer on Resilience</td>
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<table>
<thead>
<tr>
<th>20-117</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Summit &amp; Peer Exchange</td>
</tr>
<tr>
<td>- Resilience Guide</td>
</tr>
<tr>
<td>- Resilience Toolkit</td>
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</tbody>
</table>

NCHRP Synthesis 20-05/Topic 48-13 Resilience in Transportation Planning, Engineering, Management, Policy, and Administration
AASHTO 2016-2018
Resilience Research Program


CEO Engagement Forums (2017-2018)

3-Transportation Resilience White Papers (2016-2018)

Resilience Summit and Peer Exchange (2018)


CEO Primer on Transportation Resilience (2018)
Understanding Transportation Resilience: Discussion Papers

• What is the topic?
• Why is this issue critical or important to my agency or me?
• What do you want me to do?

Copies of the NCHRP resilience papers are available from Stephan Parker, TRB (saparker@nas.edu)
Understanding Transportation Resilience: An Environmental Perspective

- Heavy Rainfall & Runoff
- Flooding & Storm Surges
- Heavy Snow & Ice Storms
- High Winds & Tornados
- Hurricanes & Cyclones
- Extreme Heat & Heat Waves
- Extreme Cold
- Drought
- Wildfires
- Lightning
- Rockfalls & Landslides
- Avalanches & Mudslides
- Earthquakes & Tsunamis
- Sinkholes
- Volcanoes & Lava Flows
- Space weather & Solar Storms
- Sea Level Rise & High Tides
21st Century Climate Trends

- Hotter
- Wetter
- Weirder
Weather and Climate Risks

Role of Adaptive Strategies and Tactics in Reducing Impacts and Consequences

**Climate Changes**
- Extreme precipitation
- Rising sea levels
- Temperature spikes

**Impacts on Transportation**
- Roadway flooding
- Damage/destuction of bridges
- Pavement and rail buckling
- Subway flooding
- Seaport and airport flooding
- Slope failures
- Curtailment of barge operations

**Consequences**
- Freight traffic disrupted for days or weeks
- Power plants, water facilities, homes, businesses, hospitals cut off
- Passenger travel delays
- Higher transportation costs for government, businesses, and households
- Evacuation of urban areas

**Adaptive Strategies to Reduce Impacts**
- Retrofit facilities
- Relocate facilities
- Upgrade stormwater drainage facilities
- Build new facilities to climate-ready standards
- Protect existing infrastructure
- Incorporate climate change into maintenance cycles

**Adaptive Strategies to Reduce Consequences**
- Re-route freight and passenger flows
- Shift to alternative modes
- Land-use regulations relating to development in vulnerable areas
- Evacuation/contingency strategies
- Building in network flexibility
- Traveler information systems
- Rapid rebuilding of damaged facilities
- Improved air traffic management

Source: National Climate Assessment
One-size won’t fit all

- Major differences in
- Population
- Economic activity
- Infrastructure investment
- Resources
American Climate Refugees

2100 Projected migration linked to sea-level rise by state. Source: Nature Climate Change
Ten Essential Points

1. Resilience requires concentrated, sustained effort

2. Resilience has short-term, intermediate and long-range horizons

3. No state is immune

4. Heat waves, severe storms, and sea level rise pose the greatest threats, resulting in

5. Reduced asset performance, disruption of service, and increased costs to users and DOTs
Ten Essential Points

6. Failures erode public trust, affect local economies, and generate political blowback

7. Old disaster management approaches have been OBE’ed

8. One-size solutions don’t fit all situations

9. Political, institutional, scientific, and technical barriers challenge leadership

10. DOTs cannot go it alone
Forget the political debate, forget the national debate, forget the debate about the science; think about what you’re seeing right here. You've got to do something about it, and you've elected us to make decisions; you've elected me to make decisions, so I've got to do something about it.

Jake Day, Mayor, Salisbury, MD
Pretty grim already...

<table>
<thead>
<tr>
<th>Disaster Type</th>
<th>Number of Events</th>
<th>CPI-Adjusted Losses (B$)</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storms or Flooding</td>
<td>152</td>
<td>$899.8</td>
<td>5,328</td>
</tr>
<tr>
<td>Drought/Heat Waves</td>
<td>24</td>
<td>$232.5</td>
<td>2,993</td>
</tr>
<tr>
<td>Wildfire</td>
<td>14</td>
<td>$35.6</td>
<td>184</td>
</tr>
<tr>
<td>Winter Storm</td>
<td>14</td>
<td>$42.7</td>
<td>1,013</td>
</tr>
<tr>
<td>Freeze</td>
<td>8</td>
<td>$27.3</td>
<td>162</td>
</tr>
<tr>
<td><strong>All Disasters</strong></td>
<td><strong>212</strong></td>
<td><strong>$1,237.9</strong></td>
<td><strong>9,680</strong></td>
</tr>
</tbody>
</table>

Increasing losses, due to
- Growing economy
- Rising construction costs
- More assets in vulnerable places (e.g., coastlines)
- More recovery funds to least prepared states
- Increasing disaster severity and frequency

https://www.ncdc.noaa.gov/billions/
FY 17 FHWA Emergency Relief Funding

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Number (%)</th>
<th>Allocation (M$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storms or Flooding</td>
<td>70 (80.5%)</td>
<td>$579.7</td>
</tr>
<tr>
<td>Wildfire</td>
<td>5 (5.7%)</td>
<td>$19.8</td>
</tr>
<tr>
<td>Rock fall/Rockslide</td>
<td>5 (5.7%)</td>
<td>$14.3</td>
</tr>
<tr>
<td>Bridge Damage</td>
<td>5 (5.7%)</td>
<td>$25.3</td>
</tr>
<tr>
<td>Other</td>
<td>2 (2.3%)</td>
<td>$31.3</td>
</tr>
<tr>
<td><strong>All Events</strong></td>
<td>87 (100%)</td>
<td>$670.4</td>
</tr>
</tbody>
</table>

31 states received allocations

80.5% of events & 86.5% of $ were related to storm or flooding damage
...gonna get worse

Estimating economic damage from climate change in the United States (2080-2099)
Economic Perspectives

- Community investment
- Services provider
- Economic stimulant
- Revenue source
- Major market
- Enabler and user of other critical infrastructures such as Communications, Energy, and Emergency Services
Economic Goals

• Improve accessibility, mobility, and connectivity, across all modes, for all users
• Minimize service disruptions
• Preserve asset value
• Protect critical infrastructure components
• Stimulate the economy
• Maintain interconnectedness with other critical infrastructures
Resilience Loss—Recovery

Social and economic gain achieved through resilience improvements

“Business as Usual” Community Function (includes impacts of chronic conditions)

Acute Disturbance

Social and economic loss for all communities following an acute disturbance

Additional losses for less resilient communities

Response

Recovery

New “normal”

Model: Dr. Mary Ellen Hynes, DHS (2001); Blair Ross, ORNL; CARRI 2008 ©
5 Myths of Transportation Resilience

Myth 1: The transportation system is neither resilient nor reliable.

Myth 2: You can engineer your way to resilience.

Myth 3: DOTs have not invested in transportation resilience.

Myth 4: Resilience is just Operations “on steroids.”

Myth 5: “Extreme Weather Resilience” is the new, politically correct term for “Climate Change.”
Transportation Resilience Principles

• One strategy is not sufficient
• One size does not fit all
  – Urban v. Rural contexts
  – Sufficient v. Shoestring resources
  – Life Critical v. Non-essential missions
• One agency is not in charge
  – Communicate
  – Cooperate
  – Collaborate
  – Contract
# A Leadership Requirement

<table>
<thead>
<tr>
<th></th>
<th>EMERGENCY MANAGEMENT</th>
<th>DESIGN ENGINEERING</th>
<th>CLIMATE, COMMUNITY AND SOCIETAL CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUNCTIONS</strong></td>
<td>The assignments, tasks, and positions in a state DOT that are critical to the performance of continued transportation activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ASSETS</strong></td>
<td>The infrastructure, equipment, resources, tools, vehicles, hardware, and facilities owned and operated by a state DOT</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NETWORKS</strong></td>
<td>The relationships maintained by a state DOT with the private sector and other branches of government that ensure continuity of transportation activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SYSTEMS</strong></td>
<td>The critical technology and applications, including data, used to operate the DOT and the infrastructure and enable reliable network communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PEOPLE</strong></td>
<td>The necessary personnel needed by a state DOT to ensure resilient transportation activities</td>
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</tbody>
</table>
Weather related disruptions and loss of service have real impacts on individuals and our economy. People can’t get to work, get to school, and get to health care. People get sick. Businesses lose productivity. Families are stressed. People die. These are the reasons we need to act. - NCHRP 20-59 Panel Member

The best time to plant a tree was 20 years ago; the second best time is now. – Traditional Proverb