What Every CEO Needs to Know About Resilience
May 2017

Presented by Stephan A. Parker, Senior Program Officer, TRB

AASHTO Resilient and Sustainable Transportation Systems
The Transportation Resilience Honeycomb.
Source: Understanding Transportation Resilience: A 2016-2018 Roadmap, Fletcher and Ekern (August 2016)
Presentation Outline

• Definition and context for resilience
• AASHTO’s journey to resilience
• AASHTO SCOTSEM’s adopted resilience resources
• Restructuring
• AASHTO’s 2016-2019 resilience research program
• Ways to get involved
Promoting innovation and progress in transportation
TRB.org

Security and Emergencies Research at TRB

The mission of the Transportation Research Board (TRB) is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multidisciplinary. This page highlights recently released TRB reports, meeting announcements, requests for proposals, and other announcements related to security and emergencies. In addition, it includes links to selected security and emergency-related research activities taking place at the federal and state levels, and within the academic and international transportation communities. Finally, this page also highlights and provides links to TRB programs and activities, which are the source of most of TRB's security and emergency-related research products.

Call for Nominations: Sharon D. Banks Award for Humanitarian Leadership in Transportation

The Transportation Research Board (TRB) is seeking nominations for the Sharon D. Banks Award for Humanitarian Leadership in Transportation. This award recognizes excellence in people-oriented initiatives throughout transportation, was inaugurated in 2002 and is presented biennially. The next presentation of the award will be made during the Chairman's Luncheon on January 13, 2014.

TRB's Twitter Account Name Changes This Month to @NSAMETR

If you follow TRB's Twitter account, 'TRB' will be changing to handle from @TRBNA to @NSAMETR. TRB is part of the National Academies of Sciences, Engineering, and Medicine. Followings of @TRBNA will automatically be following @NSAMETR by the end of May 2013, and won't miss a message. For questions, contact Steve Andreeva at SATAndreeva@nas.edu.

Hearing on Infrastructure Damage and Recovery After Disasters

On April 23, 2013, the U.S. House of Representatives Committee on Transportation and Infrastructure Subcommittee on Economic Development, Public Buildings, and Emergency Management held a hearing to examine the need to control adverse effects against future disaster damage costs, and identify challenges facing the U.S. Federal Emergency Management Agency (FEMA) in preparing...

Visit the Redesigned TRB Homepage

TRB has redesigned its homepage at www.trb.org. The new homepage is mobile responsive, including mobile Announcements that are sent in the weekly TRB E-Newsletter, which has been expanded to mobile devices. Visit the homepage and provide your feedback and questions to TRB@nas.edu.

New Member of the TRB Executive Committee Announced: Dr. James M. Tian, University of Miami

Dr. James M. Tian, Professor and Chair, College of Engineering at the University of Miami, has been newly appointed to serve on the TRB Executive Committee. Dr. Tian was elected as the National Academy of Engineering in 2001. Prior to his work with the University of Miami, Dr. Tian served at the Texas A&M University as a Professor and the Director of the Petroleum Institute, until 2006.

2013 TRB Annual Meeting: Create Your MyTRB Profile Now

Create or update your MyTRB profile now if you will be attending the annual meeting of the Transportation Research Board (TRB) in Washington D.C. on May 12-16, 2013. The annual meeting of the Transportation Research Board (TRB) in Washington D.C. on May 12-16, 2013 will be held at the Walter E. Washington Convention Center. The theme of the annual meeting is "Transportation Innovation and Progress."

Guideline for Preparing Public Notification Programs at Airports

Airports and FAA must follow certain guidelines for preparing public notification programs at airports. For example, airports should not only include information about flight times but also provide an accurate and timely evacuation plan. The guidelines also include provisions for emergency responses in cases of weather-related events, such as storms or lightning strikes. The guidelines also include provisions for emergency communications in cases of weather-related events, such as storms or lightning strikes.

Guidelines for Emergency Ventilation Smoke Control in Roadway Tunnels

The National Cooperative Highway Research Program (NCHRP) Research Report 320, Guidelines for Emergency Ventilation Smoke Control in Roadway Tunnels, presents guidelines for ventilation in roadway tunnels to facilitate human evacuation and emergency responder safety. These guidelines consider the potential for smoke inhalation and the need for effective ventilation systems to control smoke levels. The report also includes recommendations for the design and operation of ventilation systems to ensure the safety of both occupants and emergency responders.

National Cooperative Highway Research Program (NCHRP)

NCHRP conducts research in problem areas that affect highway planning, design, construction, operation, and maintenance nationwide.

Syndesis of Information Related to Highway Problems

TRB's Syndesis of Information Related to Highway Problems searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute the National Cooperative Highway Research Program (NCHRP) report series, Syndesis of Highway Practice.

Highway Innovations Describing Exploratory Analysis (IDEA) Program

The Highway Innovations Describing Exploratory Analysis (IDEA) Program is designed to provide an opportunity to investigate new and unproven concepts or to evaluate novel applications of technologies that have been tested and used for highway systems practice.

Transit Cooperative Research Program (TCRP)

TCRP is an applied research program that develops new, practical solutions to problems facing transit agencies.

Symposium of Information Related to Transit Problems

TRB's Symposium of Information Related to Transit Problems searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute the Transit Cooperative Research Program (TCRP) report series, Symposium of Transit Practice.

Airport Cooperative Research Program (ACRP)

ACRP carries out applied research on problems that are shared by airport operating agencies.

Symposium of Information Related to Airport Problems

TRB's Symposium of Information Related to Airport Problems searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute the Airport Cooperative Research Program (ACRP) report series, Symposium of Airport Practice.

National Cooperative Freight Research Program (NCFRP)

NCFRP conducts research and disseminates timely findings that will inform investment and operations decisions affecting the performance of the freight transportation system.

Commercial Truck and Bus Safety Synthesis Program

TRB's Commercial Truck and Bus Safety Synthesis Program searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute the Commercial Truck and Bus Safety Synthesis Program (CTBS) report series, Synthesis of Commercial Truck and Bus Safety Practice.

Hazardous Materials Cooperative Research Program (HMCRP)

HMCRP conducts research to improve current knowledge and practice relating to hazardous materials transportation.

Marine Board

The Marine Board is a group of volunteers who report to the Office of Marine Technology and Safety, which is responsible for oversight of all aspects of marine safety. The Marine Board advises the National Academy of Engineering on maritime matters and provides a forum for exchange of information relating to new technologies, laws and regulations, economics, the environment, and other issues affecting the marine transportation system, port operations, coastal engineering, and marine governance.

Cooperative Research Programs

TRB's Cooperative Research Programs Division manages several cooperative research programs that frequently produce reports that have relevance to issues outside of the program's core focus areas.

Technical Activities Standing Committees

The National Academies of SCIENCES ENGINEERING MEDICINE
The ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events.
Disaster Resilience: A National Imperative

Four major recommendations

• Manage and communicate risk
• Measure resilience in communities
• Build community partnerships and coalitions
• Share information and data to build resilient communities
Four workstreams

1. Community Pilot Program
2. Workshops, Expert Meetings, and Activities
3. Measures and Metrics of Resilience
4. Economic Supply Chain Resilience
The Hazards and Disaster Management System

Pre-Impact Interventions
- Mitigation Practices
- Emergency Preparedness Practices
- Recovery Preparedness Practices

Post-Impact Responses
- Emergency Activities (planned and improvised)
- Recovery Activities (planned and improvised)

EVENTS

Disaster Impacts
- Physical
- Social

Hazard Vulnerability
- Hazard Exposure
- Physical Vulnerability
- Social Vulnerability

Disaster Event Characteristics
- Frequency
- Predictability
- Controllability
- Magnitude of Impact
- Scope of Impact (spatial and social)
- Duration of Impact
- Length of Forewarning

Pre-Impact

CHRONOLOGICAL TIME
- Pre-Impact
- Trans-Impact
- Post-Impact

SOCIAL TIME

### Organization of federal disaster, civil defense, and defense mobilization functions, 1950-2006

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<td>Housing and Home Finance Administration (Independent)</td>
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Source: Facing Hazards and Disasters (National Academy of Sciences, 2006)
Multidisciplinary Center for Earthquake Engineering Research (MCEER) General Framework for Quantification of Resilience: Extent of Disruption and Recovery Time

Source: Bruneau & Tierney, Resilience: Defining and Measuring What Matters (MCEER 2006)
http://mceer.buffalo.edu/
Further elaboration: MCEER resilience domains

**Technical:** Physical Systems—Location-Based & Distributed Critical Facilities

**Organizational:** Attributes, Dynamics of Organizations & Institutions

**Social:** Attributes, Dynamics of Communities and Populations

**Economic:** Attributes, Dynamics of Local and Regional Economies & Their Constituent Units (e.g. Businesses)

Source: Bruneau & Tierney, Resilience: Defining and Measuring What Matters (MCEER 2006)
http://mceer.buffalo.edu/
<table>
<thead>
<tr>
<th>Dimension/Domain</th>
<th>Technical</th>
<th>Organizational</th>
<th>Social</th>
<th>Economic</th>
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</thead>
<tbody>
<tr>
<td>Redundancy</td>
<td>Capacity for Technical Substitutions, “Work-Arounds”</td>
<td>Alternate Sites for Managing Disaster Operations</td>
<td>Availability of Housing Options for Disaster Victims</td>
<td>Ability to Substitute, Conserve Needed Inputs</td>
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<tr>
<td>Resourcefulness</td>
<td>Availability of Materials for Restoration, Repair</td>
<td>Capacity to Improvise, Innovate, Expand</td>
<td>Capacity to Address Human Needs</td>
<td>Capacity to Improvise, Innovate</td>
</tr>
<tr>
<td>Rapidity</td>
<td>System Downtime, Restoration Time</td>
<td>Time Between Impact &amp; Early Recovery</td>
<td>Time to Restore Lifeline Services</td>
<td>Time to Regain Capacity, Lost Revenue</td>
</tr>
</tbody>
</table>
Resilience quantification

\[ \bar{R} = \frac{1}{N_I} \sum_{i=1}^{N_I} \left\{ \frac{1}{N_E} \sum_{E=1}^{N_E} \int_{t_{0E}}^{t_{0E}+T_{RE}} \left\{ 1 - \frac{L(I,T_{RE})}{T_{RE}} \left[ H(t_{0E}) - H(t_{0E} + T_{RE}) \right] \right\} \cdot \alpha_R \cdot f_{rec}(t,t_{0E},T_{RE}) \cdot dt \cdot p_E(0,T_{LC}) \right\} \cdot P(I) \]

Where:

- \( N_E \): Number of extreme events expected during the lifespan (or control period) \( T_{LC} \) of the system
- \( N_I \): Number of different extreme events intensities expected during the lifespan (or control period) expected during the \( T_{LC} \) of the system
- \( T_{RE} \): Recovery time from event \( E \)
- \( t_{0E} \): Time of occurrence of event \( E \)
- \( f_{rec}(t,t_{0E},T_{RE}) \): Recovery function
- \( H(t_{0E}) \): is a step function (=0 for \( t<t_{0E} \); =1 otherwise)
- \( \alpha_R \): Recovery factor =1 for full recovery
- \( L_I(I,T_{RE}) \): Normalized loss function
- \( P(I) \): Probability that an event of given intensities happens in a given time interval \( T_{LC} \)
- \( p_E(0,T_{LC}) \): Probability that an event happens \( E \) times in a given time interval \( T_{LC} \)

Source: Bruneau & Tierney, Resilience: Defining and Measuring What Matters (MCEER 2006)
Three key themes for resilience

- **Measure**—Figure out way/s to measure resilience
- **Communicate**—New ways to talk about risk and resilience in ways that people can understand and take action
- **Connect**—Long-term change and impact with short-term decision making
Transportation context

- Multiple modes; multiple industries
- People and freight
- Massive network – central to economy
- International in scope
- Decentralized
- Public-private mix
- No one in charge
The transportation sector is central to enabling operability in all other sectors.

Levels and dependencies among the 11 critical infrastructure sectors.

AASHTO’S journey to resilience

- Understanding resilience
- Building a body of knowledge
- Reorganization supporting the effort
- Moving forward
Resilience has many faces,
... many dimensions,

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

Defend

Planned retreat

Adapt

Forced retreat

Sea Level Rise Adaptation Options

Source: Caltrans
AASHTO SCOTSESEM resilience resources


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


NCHRP Project 20-59(36)
NCHRP Project 20-59(14B)
Fundamental Capabilities of Effective All-Hazards Infrastructure Protection, Resilience, and Emergency Management for State Departments of Transportation (2015)
All hazards planning fundamentals

- **Prevention**: Capabilities necessary to avoid, prevent, or stop a threatened or actual act of terrorism.
- **Protection**: Capabilities necessary to secure against acts of terrorism and manmade or natural disasters.
- **Mitigation**: Capabilities necessary to reduce loss of life and property by lessening the impact of disasters.
- **Response**: Capabilities necessary to save lives, protect property and the environment, and meet basic human needs after an incident has occurred.
- **Recovery**: Capabilities necessary to assist communities affected by an incident to recover effectively.

Transportation agency resilience: fundamental capabilities

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<td>Planning</td>
<td>Public Information and Warning</td>
<td>Operational Coordination</td>
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<td>Intelligence &amp; Information Sharing</td>
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<td>Long-Term Vulnerability Reduction</td>
<td>Critical Transportation Infrastructure Systems</td>
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<td>Screening, Search, &amp; Detection</td>
<td>Physical Protective Measures</td>
<td>Risk &amp; Disaster Resilience Assessment</td>
<td>Operational Communications</td>
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<td>Supply Chain Integrity &amp; Security</td>
<td>Threat &amp; Hazard Identification</td>
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<td>Training and Exercises</td>
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Source: AASHTO. Fundamentals of Effective All Hazards Security and Resilience for State DOTs, 2015
## Transportation agency resilience: CRP resources for fundamental capabilities

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<td><strong>Planning:</strong> Guide to Emergency Response Planning at State Transportation Agencies</td>
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<td><strong>Public Information and Warning:</strong> Communication with Vulnerable Populations</td>
<td>FloodCast</td>
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<td>Training and Exercises: Guidelines for Transportation Emergency Training Exercises</td>
<td>ICS Training for Field Level Transportation Supervisors and Staff</td>
<td>Transportation Emergency Response Application</td>
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Moving forward

“Disaster resilience is everyone’s business and is a shared responsibility among citizens, the private sector, and government. Community leaders and government officials face decisions every day that may pit short-term interests against longer-term goals. Increasing resilience to disasters will require decisions and actions that are informed and forward-looking.

“Although disasters will continue to occur, actions that move the nation from a reactive to a proactive approach will reduce many of the societal and economic burdens and impacts that disasters cause. Building the nation’s resilience is a long-term process, one that will be socially and politically challenging, but the reward for our efforts will be a safer, healthier, more secure, and more prosperous nation.”

*The National Academies, 2012*
AASHTO 2016-2019 resilience research program

- CEO Engagement Forums (2017-2018)
- Resilience Summit and Peer Exchange (2018)
- 3-Transportation Resilience White Papers (2016-2018)
- CEO Primer on Transportation Resilience (2018)

NCHRP 20-59(54)
NCHRP 20-59(55)
NCHRP 20-117
NCHRP Project Panel 20-59
Surface Transportation Security & Resilience Research

• NCHRP 20-59(117) Deploying Transportation Resilience Practices in State DOTs (2017-2019)
• Resilience Research Roadmap (Pre and Post Summit versions) (2017-2019)
• Transportation Resilience White Papers (2017)
  – Understanding Transportation Resilience: An Environmental Perspective
  – Understanding Transportation Resilience: An Economic Perspective
  – Understanding Transportation Resilience: A Cyber Perspective
• CEO Primer on Transportation Resilience (2017-2019)
• CEO Engagement Forums (2017-2018)
Ways to get involved

- SCOTSEM & RSTS (Soon to be TSS&R)
- TRB Committee on Critical Infrastructure Protection (ABR10)
- NCHRP Resilience Research Road Map Needs Solicitation
- 2018 Transportation Resilience Summit and Peer Exchange
Promoting innovation and progress in transportation

TRB.org

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TRB’s work relies on volunteers, and seeks to involve transportation professionals at every stage of their career. Get involved by receiving updates, volunteering, or responding to proposals:

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- Volunteer
- Respond to Requests for Proposals

Publications

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