



Peer Exchange Report

Resilience and TSMO

Virtual Peer Exchange
June 23, 2026

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Key Takeaways

The National Operations Center of Excellence (NOCoe) hosted the TSMO for Resiliency Peer Exchange on June 23, 2026, a virtual gathering, to examine how transportation systems management and operations (TSMO) practices support the resilience of the transportation system. Participants included state departments of transportation (DOTs), a metropolitan planning organization (MPO), a regional water management authority, and partner organizations. The conversation across five sessions returned to a few consistent learnings:

- **Funding** is the field's binding constraint, not technology. Every presenting agency named it independently, and it topped the roundtable's live poll as the day's biggest challenge.
- Resilience still has **no foothold in the formal processes** that decide which projects get built. The Wilmington MPO (North Carolina) and North Carolina DOT both described prioritization and scoring formulas that treat resilience spending as pure added cost, with no accepted way yet to credit the risk it avoids.
- Dedicated **resiliency-manager roles** are an emerging organizational gap. Hawaii DOT and Florida DOT each named the absence of one as their agency's biggest structural shortfall.
- Frontline, operator-level **relationships** matter as much as formal plans. Maryland SHA and MDTA's Key Bridge response and PennDOT's I-95 Cottman Avenue response both relied on phone calls and radio access built long before the crisis.
- **Tools built for crisis response** keep paying off afterward. RITIS, StreetLight Data, and portable camera fleets that Maryland and Pennsylvania stood up for their respective incidents went on to serve World Cup planning. NCDOT's flood-gauge network has scaled from roughly 50 to more than 780 since Tropical Storm Debby proved its value.
- **Resilience and reliability are not the same thing**, and the field still lacks metrics that make the distinction, a gap Jason Dicembre of Maryland SHA and others raised directly.
- **Unexpected partners closed real gaps**. The Eastern Transportation Coalition adjusted Waze's routing for Maryland's detours, Vail Resorts is a formal partner in Tahoe's emergency planning, and city police ran Philadelphia's local detour so PennDOT could focus on the highway itself.

Background

TSMO generally focuses on day-to-day operations: managing congestion, incidents, and predictable demand. Resilience focuses on what happens when the system is stressed or broken, and how TSMO strategies can accelerate recovery.

NOCoE and ITE's Resiliency Great Ideas Group developed this peer exchange to attempt to answer that question and included attendees with a deliberate broad mix of agency types and hazard exposures: state DOTs, MPOs, and a river authority that span geographies including islands, coasts susceptible to hurricanes, regions with wildfires, agencies exposed to river flooding, and urban environments with catastrophic infrastructure failures.

The day ran across five sessions: a briefing from ITE's Resiliency Great Ideas Group to frame the state of the conversation through three practitioner panels on planning, operational response to infrastructure failure, and extreme weather, and closed with a full-group roundtable discussion. NOCoE asked participants to share their own agency's experience and to identify where they need research, tools, training, or policy support to advance resilience work. The exchange deliberately set aside man-made and cyber threats as NOCoE and ITE plan a follow-up webinar to cover that ground.

Session 1 – Setting the Stage

Nicholas Ramfos welcomed attendees and stated the day's key question: what happens when the system is stressed or broken, and how do TSMO capabilities help to recover it faster? Ramfos described the group in the room as a deliberately broad mix of state DOTs, an MPO, a river authority, and partner organizations. He indicated that man-made disasters and cybersecurity resilience would be covered during a separate NOCoE webinar session in the future.

Matt Hardy, Deputy Executive Director of ITE, and Aimee Flannery, Ph.D., PE, of Jacobs, briefed the group on the origin and mission of ITE's Resiliency Great Ideas Group, which Flannery chairs. ITE identified resilience as a "developing trend" in January 2024. ITE responded with a plenary session in Philadelphia that July, a resilience-focused issue of the ITE Journal that October, and a Sandbox Competition on resilience later that year. The resulting Great Idea Group, alongside efforts on artificial intelligence, road safety audits, and people-centered mobility, exists to build practitioners' awareness of resilience considerations in daily work, better understand the transportation system's ability to withstand and recover from natural and direct threats, communicate the system's vulnerabilities, and identify management and investment strategies that reduce those vulnerabilities. Group leadership includes Flannery as chair, Brad Freeze of the City of Nashville as vice chair, Vandana Murtha as secretary, Beverly Kuhn as webinar coordinator, and Hardy as ITE staff liaison.

The group's action plan runs through the rest of 2026, beginning with a conference session which was held at the ITE Virtual Spring Conference in March, resilience case studies from Florida DOT and North Carolina DOT slated for April publication, a short technical paper distilling the spring conference session in May, an accepted session at the ITE Annual Meeting in July, this peer exchange itself, and a "Transportation Resilience Primer" technical brief planned for November that will cover definitions, examples, case studies, and tools spanning coastal, cyber, natural-hazard, and network resilience.

<i>Title</i>	<i>Project Type</i>	<i>Description</i>	<i>Publication Date: Proposed</i>	<i>Project Champion</i>
Resilience in Practice: How it Shapes Your Job and Your Agency	Conference Session	Conference session at the 2026 ITE Virtual Spring Conference	March 2026	Leadership Group
Transportation Resilience Case Studies	Case Studies	Develop case studies from Florida DOT and North Carolina DOT to be published and branded by ITE.	April 2026	Aimee Flannery
Resilience In Practice: How it Shapes Your Job and Your Agency	Quick Bite	Turn the presentations and discussions from the 2026 ITE Virtual Spring Conference session into a Quick Bite	May 2026	Leadership Group
Perspectives on Implementing Transportation Resilience Strategies	Conference Session	Conference session at the 2026 ITE Annual Meeting. This was accepted.	July 2026	Beverly Kuhn
TSMO and Resilience	Virtual Peer Exchange	Workshop on the topic of transportation resilience and transportation operations. Developed in cooperations with NOCoE and TSMO Council This will be conducted as a virtual peer exchange.	July 2026	Beverly Kuhn
Transportation Resilience Primer	Technical Brief	Follow-on to the ITE Journal (October 2024) to provide definitions, examples, and resources related to the topic of transportation resilience including: • Defining resilience (coastal, cyber, natural hazards, network) • Overview/examples of what is transportation resilience • Case Studies: Various examples including PROTECT. • Tools • PROTECT formula grant case studies	November 2026	TBD (Matt Hardy to support)

Hardy anchored the briefing in the Francis Scott Key Bridge collapse in Baltimore, using it to draw a distinction between asset resilience and system resilience that recurred throughout the day: the cargo ship was not resilient to its own electrical malfunction, and the bridge was not resilient to the resulting collision. Hardy argued that the transportation system in Baltimore, has proven resilient more than two years after the bridge fell given that traffic in the region is still flowing.

Flannery, who has worked in resilience for roughly a decade and a half, named documentation of benefits as the field's most persistent gap, a challenge she compared to the early years of justifying intelligent transportation systems investment, since resilience spending mitigates events that have not yet happened. She credited the PROTECT program, created under the Infrastructure Investment and Jobs Act with helping close that gap by dedicating formula funding specifically to probable but not-yet-occurred risks.

"Was the ship resilient to an electrical malfunction? Not really, because it kind of lost power and started drifting. Was that bridge resilient to that event? Well, not really, because it fell down, but was the transportation system in Baltimore resilient to it? And I would argue, yes, it was."

— Matt Hardy, ITE

"How do you understand how to make that investment for something that maybe hasn't happened yet? Putting investments into something that may happen is very challenging."

— Aimee Flannery, Jacobs

Session 2 – Resiliency Planning Use Cases

Moderator Sean Flaherty of HDR opened this session as a look at planning-level resilience work across three different agency types: a state DOT, an MPO, and a state DOT operating in a very different hazard context. Three practitioners presented in sequence, followed by a joint discussion.

Hawaii Department of Transportation

Landon Kaya, of the Hawaii Department of Transportation's (HDOT) Highways Division Planning Branch, opened with the specific constraints that island geography places on resilience planning: no alternate mainland routes, a limited road network, supply-chain vulnerability, and terrain that forces one-way-in, one-way-out routes in places like Makapu'u Point. Hawaii's mountainous terrain and limited developable space mean HDOT has less room to build redundancy, and importing construction materials as an island state costs more, which are both reasons, Kaya argued, that a more resilient highway network directly reduces costs and community disruption over time.

Kaya walked through three recent hazards that reshaped HDOT's thinking. Kona Low¹ flooding in Waialua, on Oahu's North Shore, left 20 properties as total losses and damaged roughly 260 homes (17 percent of all homes on Oahu) badly enough that officials deemed them uninhabitable without major repairs. Paradoxically, Hawaii has been receiving less annual rainfall overall even as individual storms are more intense. That drying trend helped set the conditions for the 2023 Lahaina wildfire on Maui, which spread across 2,170 acres, killed roughly 102 people, and destroyed about 2,200 buildings; HDOT has since raised wildfire prevention as a higher priority than it held before Lahaina. A magnitude-8.8 earthquake off Russia's coast produced tsunami waves over 5.5 feet on Maui and resulting gridlock which is a reminder that as an island state, Hawaii has only hours to respond before traffic gridlocks.

Funding scarcity compounds these hazards. Hawaii received the third-lowest 2026 apportionment nationally under the Infrastructure Investment and Jobs Act, at \$242.5 million, even though HDOT maintains 25.6 percent of the state's lane miles and carries 55.5 percent of its vehicle miles traveled. HDOT is now developing its first Resilience Improvement Plan under the PROTECT formula program. The plan will overlay multiple hazard layers against HDOT's assets in an interactive map, prioritize eligible projects by vulnerability, coordinate with the department's Mid-Range Transportation Plan and its financial constraints, and extend resilience thinking into HDOT's own maintenance operations, including its rockfall program. Community input flows in through neighborhood boards and public scoping meetings, and HDOT measures success partly by how well a project protects native and endangered species alongside infrastructure performance. Kaya named the department's lack of a dedicated resiliency manager as its biggest organizational gap.

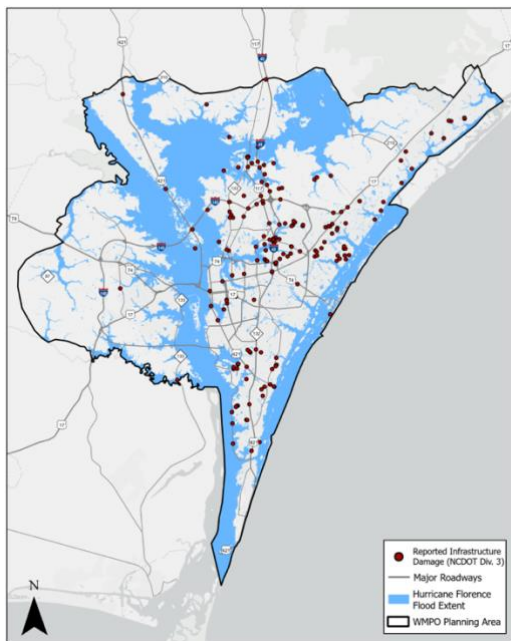
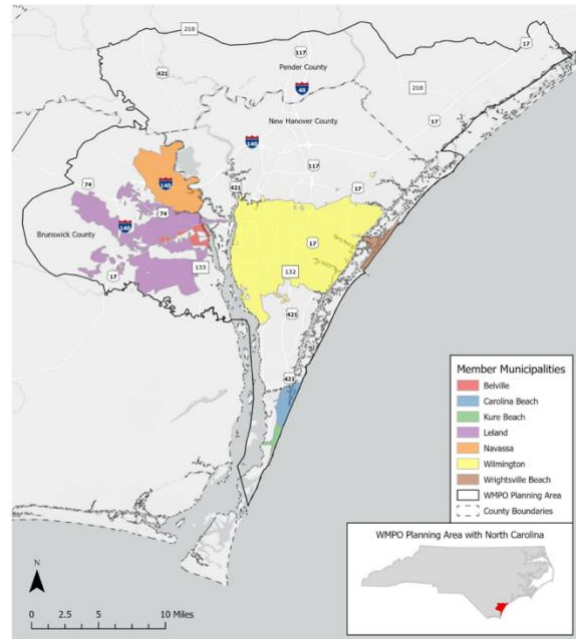
¹ A Kona Low is a seasonal (November -May), cold-core low-pressure weather system that forms west or northwest of the Hawaiian Islands that reverses normal trade winds, bringing heavy rain, flash floods, and southerly winds to areas that are usually dry.

"We received the third-lowest 2026 IJA apportionment, with \$242.5 million — we maintain 25.6 percent of Hawaii's lane miles while also serving 55.5 percent of all the average vehicle miles traveled annually." — Landon Kaya, Hawaii DOT

Wilmington Metropolitan Planning Organization

Abby Lorenzo, Deputy Director of the Wilmington Metropolitan Planning Organization (WMPO) in North Carolina, described a region of 494 square miles and roughly 300,000 people spanning seven municipalities and three counties; a 13-member board governs the MPO. WMPO's network includes 2,728 center-lane miles, 1,000 of which are owned by North Carolina DOT (NCDOT) and 1,728 owned locally, along with 148 NCDOT bridges, several of them movable spans crossing the Cape Fear River and the Intracoastal Waterway. The region is among the fastest growing in the country, ranking seventh nationally in population growth and ninth in employment growth, with trade and transportation, education and health services, and tourism as its largest job sectors.

Much of that growth sits close to major economic and military assets exposed to natural hazards. The Port of Wilmington generates an estimated \$16.1 billion in economic input, supports more than 88,000 jobs, and is one of 15 strategic seaports designated by the U.S. Department of Defense; Military Ocean Terminal Sunny Point, the largest U.S. Army ammunition depot on the East Coast, along with Fort Bragg and Camp Lejeune, all depend on continued access. The region sits at the confluence of the Atlantic Ocean, the Intracoastal Waterway, the Cape Fear River, and extensive wetlands, and its humid subtropical climate brings hurricanes, flash flooding, extreme heat and wind, tornadoes, tidal flooding, wildfire, and, occasionally, snow and ice.



Lorenzo cited three recent events as evidence of that exposure. A May 2023 rain event dropped more than 10 inches of rain in four hours with no warning, flooding roads and stranding school buses in Brunswick County. Potential Tropical Cyclone Eight struck September 16, 2024, a week ahead of Hurricane Helene, dropping more than 20 inches of rain across Brunswick and New Hanover counties and cutting off Southport entirely, leaving ferry service as the only way in or out. Hurricane Florence, which made landfall as a Category 1 storm at Wrightsville Beach in September 2018 after weakening from a Category 4, crawled through the region at roughly 2 miles per hour and dropped 20 to 30 inches of rain, flooding Interstate 40 and several other major roads and cutting Wilmington off from resupply by anything but boat and helicopter.

Closer to home, the Cape Fear Memorial Bridge underwent its first-ever full bidirectional closure from January through May 2024 for structural member replacement, diverting roughly 35,000 daily vehicle trips from a bridge that normally carries more than 70,000. WMPO's response combined an activated

Emergency Operations Center with weekly situation reports to stakeholders, coordinated detour routes, signal-timing adjustments, and expanded transportation demand management: the MPO worked with NCDOT and Wave Transit to add RideMicro microtransit service during the closure, backed by additional marketing,

and built a "Commuter Friendly Employer Toolkit" offering major employers guidance on telework policy and vanpool incentives.

That experience is now shaping WMPO's planning process directly. Federal planning factors require MPOs to weigh both resilience and TSMO, and WMPO's *Metropolitan Transportation Plan* now carries "Resilient" as a formal goal that shapes project-prioritization criteria. A joint 2025 *ITS Plan Update* with NCDOT drawing on the North Carolina Port Authority, emergency management coordinators, and public safety and city and county staff named resiliency as one of five focus areas and recommended that WMPO develop its own Resilience Improvement Plan, which will begin in state fiscal year 2027 under the PROTECT program. The MPO did not secure PROTECT funding for the ITS Plan Update itself and covered it instead with planning funds and local member contributions. Lorenzo named North Carolina's project-prioritization process as the thing she would most want to change: it does not currently score for resilience at all.

*"Currently, resiliency is not factored in as part of how projects are evaluated and prioritized – if I could change something, it would definitely be to include a metric for that."
– Abby Lorenzo, Wilmington MPO*

Florida Department of Transportation

Alexandra Lopez, TSMO Program Engineer for Florida DOT's District 4, described her district as a coastal, high-growth, multimodal region of five counties and roughly 4 million people, operating TSMO 24 hours a day. The district's TSMO Master Plan identifies 1,211 miles of "strategic network," including interstates, major arterials, freight connectors, and regional transit corridors. These are managed using seven stress indicators mapped directly to TSMO goals: congestion, crashes, signal density, bottlenecks, truck activity, flooding and climate exposure, and transit frequency.

The Master Plan organizes its response around a Detect-Manage-Inform framework:

- **Detect** covers real-time monitoring, weather awareness, and incident verification
- **Manage** covers coordinated response and traffic-flow control
- **Inform** covers traveler alerts and connected-vehicle messaging.

Road weather information systems, integrated corridor management, dynamic speed limits and queue warning, smart work zones, and connected-vehicle and vehicle-to-infrastructure technologies each score against all three of the plan's outcome measures: mobility, reliability, and resilience, while adaptive signal control scores against mobility and reliability alone.

The district has committed to five targets by 2031: ten flood-prone roadways equipped with water-level sensors, ten roadway segments piloting emerging technology, 150 miles of expanded real-time arterial monitoring, ten congested corridors with advanced signal control, and 15 high-crash locations with intersection collision avoidance. This will include an estimated \$48 million investment phased through the FY27–FY47 FDOT Work Program. District 4's most visible near-term outcome is a new regional Traffic Management Center; the district currently leases space in a Broward County-owned building it has outgrown, and the new facility will be FDOT-owned and modernized.

The plan for a new physical TMC drew a question in the discussion period from Kevin Riley of Caltrans, who asked whether a fully virtual, zero-brick-and-mortar model made more sense in the years since the pandemic. Lopez said FDOT evaluated exactly that model around 2020 and 2021 and concluded a physical facility is still necessary. The building itself houses network, fiber, and switching infrastructure, and agencies need a physical hub where partners can convene during hurricanes and other emergencies. She was open to a hybrid model, and open to questioning whether video walls specifically are still worth the investment, but not to abandoning a physical TMC altogether. Like Kaya, Lopez named the absence of a dedicated resiliency manager as a gap in her agency's structure.

"I really see it very difficult, at least in Florida, for us to move away from that brick-and-mortar TMC and going fully virtual – you always need that one place where you can come together, especially during emergencies." – Alexandra Lopez, Florida DOT

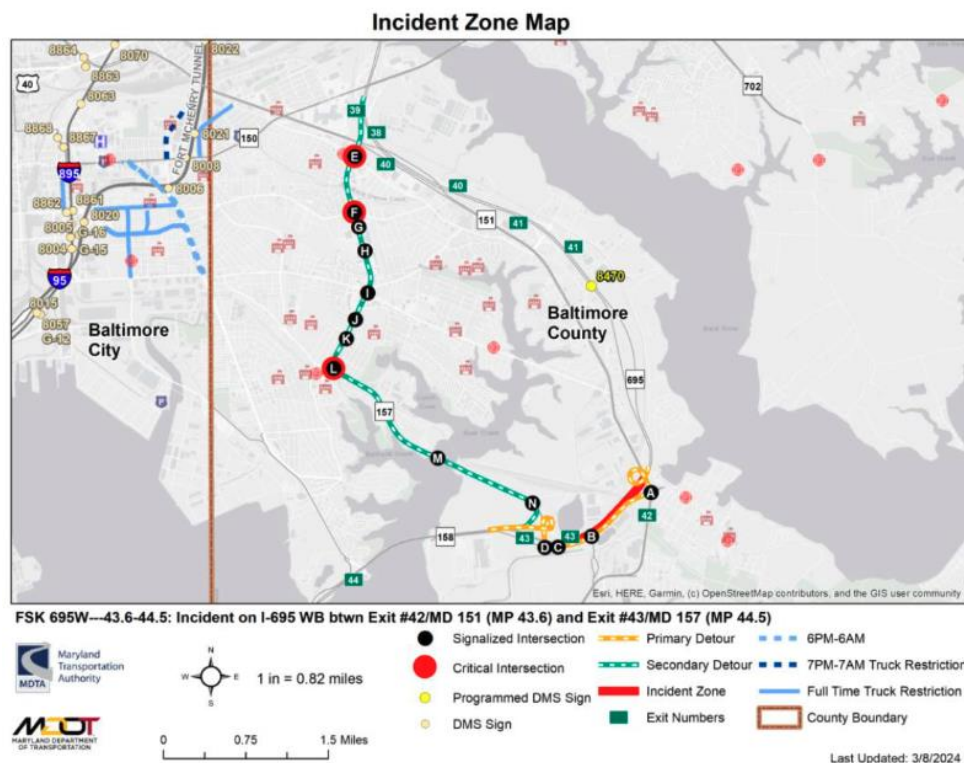
Funding scarcity was a theme that ran through all three presentations, and none of the three agencies has yet built resilience scoring into how it prioritizes projects. Brick-and-mortar traffic management centers remain operationally necessary in every case, even where virtualization is technically possible, and both Hawaii DOT and Florida DOT identified the same organizational gap: neither has a dedicated resiliency manager role.

Session 3 – Operational Resilience: Coordinating Across Infrastructure Failures

Moderator Beverly Kuhn of C-DEX Advisors introduced this session as the day's most operationally intense, covering two of the highest-profile U.S. infrastructure failures in recent memory: the Francis Scott Key Bridge collapse in Baltimore and the I-95 Cottman Avenue bridge fire in Philadelphia.

Maryland State Highway Administration and Maryland Transportation Authority

Jason Dicembre, of the Maryland State Highway Administration (SHA), and Jason Pulliam, Director of Traffic Management and Technology for the Maryland Transportation Authority (MDTA), walked the group through the March 2024 collapse of the Francis Scott Key Bridge. At 1.6 miles long with a 1,200-foot main span and 185 feet of clearance below, the bridge was the second-longest in the Baltimore region behind the Chesapeake Bay Bridge, and one of only three crossings of Baltimore Harbor alongside the Fort McHenry and Baltimore Harbor tunnels. It carried an estimated 12.5 million vehicles in 2023, which was more than 34,000 a day and represented 15 percent of all traffic across the harbor's three crossings. Crucially, it was the only crossing permitted for certain classes of hazardous-materials shipments.



MDTA owned and maintained the bridge itself, while SHA maintained the detour roadways alongside it, making the response cross-jurisdictional from the first minutes. Existing interoperability proved decisive: SHA's CHART safety patrol radios were already able to switch to MDTA's Key Bridge maintenance channel, letting units coordinate directly without routing through a traffic management center. Plus, only a glass door separates MDTA's Emergency Operations Center from the agency's police force, a proximity that lets law enforcement close the bridge to traffic within minutes. The agencies had updated their detour plans roughly two weeks earlier, and the plans still shifted multiple times over the following days, first for traffic performance and later for security and dignitary visits.

The response reshaped how both agencies operate. Maryland expanded its use of the University of Maryland's Regional Integrated Transportation Information System (RITIS) analytics platform and INRIX travel-time data to monitor detour performance sitewide, rather than the roughly 20 percent of signals it had covered before the collapse. The agencies changed how their message signs handle competing information, letting travel-time and incident messages rotate rather than one blocking the other, and stood up a public "Travel Time Routes" webpage that refreshes every five minutes, far faster than the standard 15-minute cycle for dynamic message signs. The Eastern Transportation Coalition (ETC) helped to adjust Waze's routing weights toward the preferred detours, a level of cooperation Dicembre noted is unusual for navigation companies. MDTA, for its part, worked with the Maryland Motor Truck Association within 48 hours to establish dedicated hazmat detour routes with local first responders, rather than leaving freight routing to chance.

Longer term, both agencies reinstituted a four-year review cycle for detour and contingency plans that had drifted toward six years or an ad hoc basis, expanded detour pre-planning to signalized U.S. routes beyond the controlled-access highway network, and renewed operator-level "scan tours" between SHA and MDTA staff after realizing that frontline relationships, unlike relationships at the leadership level, had quietly eroded over time.

"In the heat of the moment, to have Jason pick up the phone and call me was extremely successful. If you've not built any of those relationships around your area of responsibility, I can't tell you, in a sense of an emergency, how vital those relationships are." — Jason Pulliam, MDTA

Pennsylvania Department of Transportation

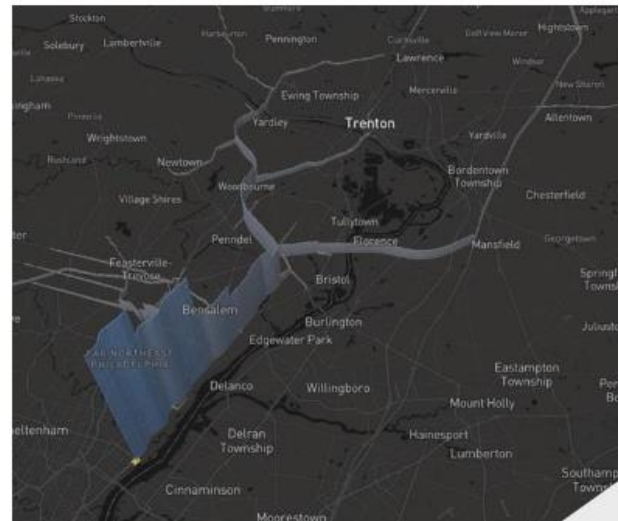
Dave Adams, Senior Manager of Traffic Operations for PennDOT District 6, described the early-morning fire that destroyed a section of I-95 at the Cottman Avenue off-ramp in Philadelphia on June 11, 2023. At 6:19 a.m., a tanker truck fire ignited beneath the highway; two Traffic Management Center operators on duty, both with prior fire-service backgrounds, spotted it on camera within two minutes and moved quickly to get state police and PennDOT maintenance crews on scene. The truck's driver, Nathaniel Moody, was the incident's only fatality. The northbound bridge collapsed outright. PennDOT later found the southbound structure severely compromised beyond repair and demolished it.

District 6's regional Traffic Management Center, a \$40 million facility with 500 cameras and more than 200 message boards, had opened only three months earlier, itself partly a legacy of lessons from Philadelphia's 2015 papal visit. PennDOT's incident command center activated by 9 a.m. that Sunday, and Adams coordinated the early response by phone during a 90-minute drive into the city, targeting reopening before Monday's morning commute.



StreetLight Data's origin-destination analysis shaped nearly every decision that followed. The data showed southbound traffic on the corridor drawing roughly 30 percent of its volume from Woodhaven Road and 16 percent from Academy Road, with the remainder split among New Jersey crossings. Northbound traffic drew nearly 30 percent from Vine Street and Center City via I-76, with the rest split among crossings from Delaware and New Jersey. That breakdown pointed PennDOT toward a specific detour routing traffic via Woodhaven Road to Route 1 and I-76 to I-676. PennDOT coordinated with New Jersey, Delaware, and Maryland DOTs for through-traffic messaging. Unable to fabricate static detour signage in time, the team repurposed construction message trailers, while city police managed the local detour around the clock. That coverage freed PennDOT to focus on restriping the local network from one lane per direction to two, adjustments that included reshaping an island on State Road and closing a ramp near the Betsy Ross Bridge. PennDOT shifted Freeway Service Patrol as conditions evolved, extending patrol zones to cover the detour routes and adding a dedicated emergency truck to US-1.

PennDOT reopened the roadway in stages, mirroring the bridge's original three-stage construction. A temporary "Stage 0" filled the collapsed ramp area with lightweight glass aggregate, creating three 11-foot lanes at a reduced speed limit, with trucks restricted to the center lane. Heavier fill wasn't an option given a large sewer line beneath the roadway. Initial recovery took 12 days to reopen the roadway, while the full structural rebuild took roughly a year. PennDOT posted a livestreamed recovery camera publicly at the Governor's office's request. It drew around 2,000 regular viewers during construction and peaked near 8,000 just before reopening, a visible sign, in Adams's telling, that PennDOT was working around the clock. PennDOT later reused the same data tools it had deployed for the response, including StreetLight Data and portable cameras it first brought in from other parts of the state, to manage parking and traffic around FIFA World Cup events.



The incident left PennDOT with lasting changes: minimum Traffic Management Center staffing rose from two operators to three at all times, portable cameras and message boards became a standing equipment class rather than an afterthought, and the agency's relationship with city police for local detour management deepened. Later in the day's roundtable, Adams raised a related but separate challenge his district is still working through: copper wire theft, which is complicating maintenance across the Philadelphia area and pointing PennDOT toward a long-term switch to aluminum wiring.

Portables were previously an afterthought. PennDOT purchased and deployed 32 Portable CMS's and 8 Portable CCTV's." – Dave Adams, PennDOT

Across both cases, agencies found that partners they had not expected to rely on turned out to matter most, and that the data and monitoring tools they built under crisis pressure went on to serve planned events long after the emergency ended. In both Maryland and Pennsylvania, the most durable changes coming out of these incidents were staffing minimums and revised planning cycles, not new hardware.

Session 4 – Resiliency for Extreme Weather

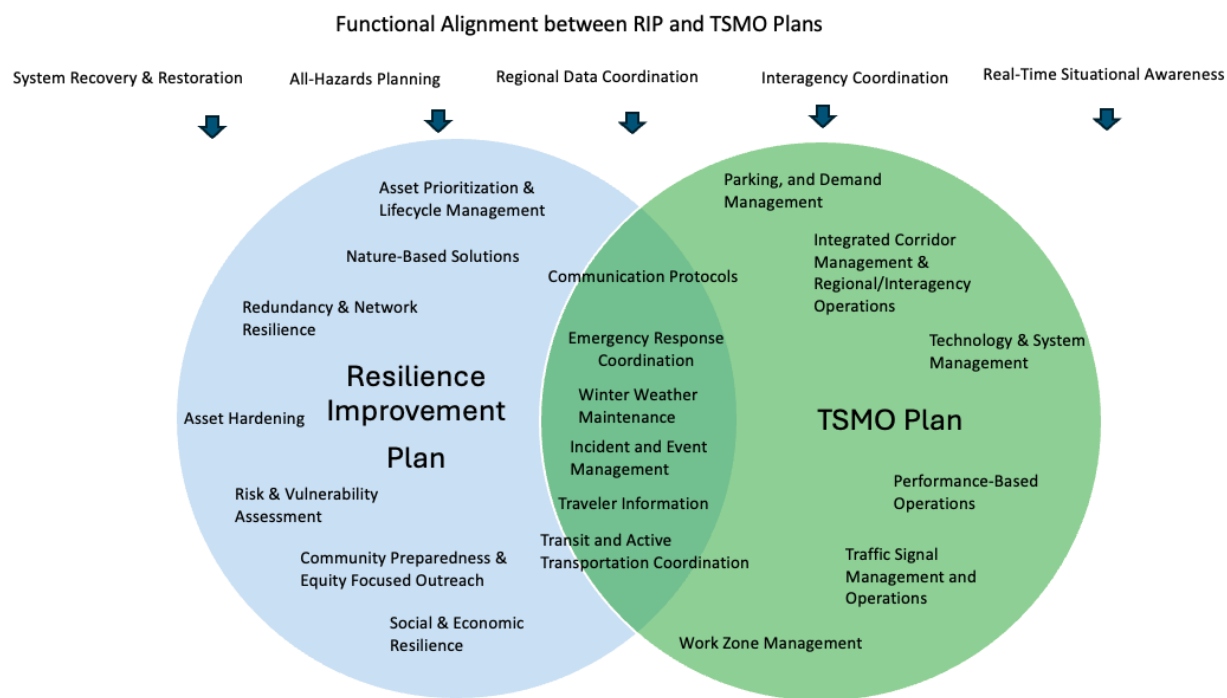
Moderator Aimee Flannery of Jacobs introduced three distinct hazard profiles for this session: wildfire and snow, riverine flooding, and hurricanes and asked the group to listen for common threads across all three.

Tahoe Regional Planning Agency

Rachael Shaw, Associate Transportation Planning Analyst with the Tahoe Regional Planning Agency (TRPA) presented on their resiliency efforts in the face of both wildfire and snow. TRPA is the MPO for the Lake Tahoe region, spanning portions of California and Nevada, five counties, and one city, with a resident population of about 55,000 that swells to as much as 350,000 on peak visitation days. A bi-state compact constrains growth in the basin, and the region's five two-lane highways and single four-lane route leave little redundancy if any of them close.

The 2021 Caldor Fire, which burned 220,000 acres and forced the evacuation of the South Shore of Tahoe, destroyed no homes within the basin itself but produced severe evacuation congestion. Shaw drew a careful boundary around TRPA's role: the agency's planning work is not an evacuation plan. That responsibility belongs to emergency managers, fire agencies, and law enforcement. But TRPA supports the coordination among them. One lesson from Caldor has stuck: transit agencies and school districts improvised by loaning buses to evacuate residents without vehicles, an ad hoc response TRPA now wants to formalize into protocol.

Regional projections show surrounding cities growing 24 to 30 percent over the next 25 years, and Tahoe's elevation and cooler temperatures increasingly draw visitors during regional heat waves, adding congestion, crashes, and emissions independent of any single disaster. With \$1.8 million in PROTECT funding, TRPA is developing two complementary plans: a Resilience Improvement Plan paired with a Regional Emergency Communications and Transportation Strategy addressing unplanned events and extreme weather, and a separate TSMO Plan, funded through California MPO dollars, covering the region's other two seasons: winter snowfall and summer construction. A functional-alignment framework ties the two efforts together across two dozen coordinated planning categories, from emergency response coordination and asset hardening to community preparedness and regional data coordination.



The PROTECT-funded work begins with what TRPA calls a Baseline Assessment: structured interviews and data collection with the agencies that mobilize people during an emergency, including fire districts, the sheriff's office, transit providers, and large private employers such as Vail Resorts, which has invested heavily in its own shuttle transportation. That assessment will feed a risk-based vulnerability assessment measuring exposure, sensitivity, and adaptive capacity for the basin's transportation assets against wildfire, flooding, and snow-loading hazards, ultimately producing a prioritized list of projects eligible for PROTECT funding. TRPA currently has an open request for proposals out for a data-procurement vendor to obtain the necessary data for the assessment.

"Our planning effort is not an evacuation plan. That is not our role as an MPO, but we're here to support the emergency managers, the fire departments, the local law enforcement." – Rachael Shaw, TRPA

San Antonio River Authority

Erin Cavazos, of the San Antonio River Authority (SARA), brought a different viewpoint to the session: SARA is a water-management authority, not a transportation agency, covering four counties across most of the San Antonio River Basin. Locals know the region as "Flash Flood Alley," where terrain forces tropical air up against cooler air to produce sudden, intense rainfall and conditions that intersect directly with Interstate 35.

Cavazos centered her presentation on a June 12, 2025, flash flood that dropped roughly 4 inches of rain per hour at the airport and 6 to 7 inches over the affected creek, sweeping away more than a dozen vehicles at a crossing near Loop 410. SARA's investigation ruled out the obvious suspects (a bridge and a low-water crossing, both equipped with working flashers) and traced the actual failure point to a low spot in a frontage road approaching the bridges, a location standard hydraulic modeling treated as part of the streambank rather than a monitored crossing. There was no guardrail at the point where the flood swept the vehicles away, and unlit conditions made the water's true depth deceptive to drivers in the dark.

SARA's monitoring network covers more than 200 high-water detection sites countywide, feeding a public website, opt-in text alerts, and integrations with Waze, Google Maps, and Apple Maps. Apple Maps has proven a persistent problem: if a driver ignores a posted closure and drives through anyway, the app will automatically clear the closure for other users, and SARA is working with Apple to gain recognition as an authoritative source that overrides that behavior. A newer analysis method, combining FEMA water-surface-

elevation data with state LIDAR-derived road elevation, found more than 1,000 roads that flood within a tolerable range and 13 that flood more than 20 feet deep in just a 10-year storm, not even a major-storm threshold. Roughly three-quarters of these newly identified risk locations sit on roads running alongside creeks rather than crossing them, meaning they receive less design and monitoring attention than crossing points do.

Cost constrains how far SARA can extend its existing approach: each of its 200 sensor sites costs roughly \$10,000 a year to maintain, making a sensor at every one of the newly identified 1,000-plus risk locations financially out of reach. SARA instead prioritizes new gates and sensors using incident history, flood depth, visibility, speed limit, and traffic volume, while exploring remote-verification cameras and rainfall-model-triggered alerts as lower-cost alternatives to a sensor at every site. Cavazos closed by pointing to North Carolina's flood-information tools as a model worth emulating which was a direct hand-off to the presentation that followed.

"There was really no way for anyone to turn around, and they're being surprised by this situation. The depth of the water wasn't clear; it was deceptively deep." — Erin Cavazos, San Antonio River Authority

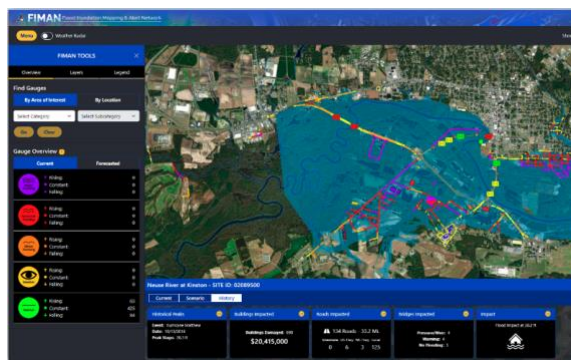
North Carolina Department of Transportation

Dom Ciaramitaro, State Traffic Systems Operations Engineer for NCDOT, and Kurt Golembesky, of the department's Hydraulics Unit, presented NCDOT's evolving suite of flood-warning tools. Ciaramitaro joined the department's traffic operations unit around the time of Hurricane Florence in 2018, a comparatively predictable storm that still closed roughly 2,500 roads. Hurricane Helene, by contrast, struck the North Carolina mountains, a region unaccustomed to hurricane impact, with damage driven by terrain rather than sheer rainfall volume. Then, in February 2026, northeastern North Carolina received 18 inches of snow over a single weekend alongside a coastal tropical-storm-type impact, forcing crews to use a front-end loader to push a storm berm and clear snow simultaneously, a combined response NCDOT had never had to run.

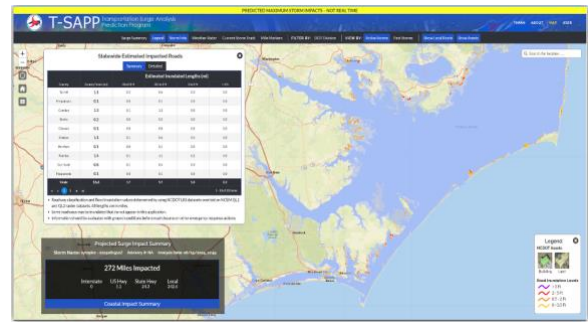
NCDOT operates five Traffic Management Centers alongside a Statewide Transportation Operations Center, connected through dedicated communications and continuity-of-operations planning so the network keeps functioning if any single center goes down. Its Incident Management Assistance Patrol covers roughly 1,400 route miles and logs about 92,000 stops a year through a hybrid staffing model of NCDOT employees and contracted responders, and the department maintains roughly 1,200 CCTV cameras and 350 dynamic message signs statewide. Ciaramitaro summarized NCDOT's philosophy simply: be predictable. The department treats major storm response as a scaled-up version of routine incident management, rehearsing hurricane and winter-weather exercises, including full TMC-shutdown contingency drills, multiple times a year, while staying flexible enough to adapt when something becomes genuinely unpredictable.

Golembesky then walked through three purpose-built hydraulics tools:

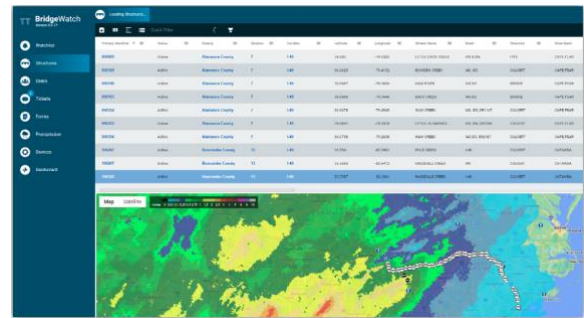
FIMAN, the Flood Inundation Mapping and Alert Network, traces back to North Carolina's emergency management agency around 2000; NCDOT joined after Florence and now monitors 4,000 miles of roadway through more than 780 flood gauges feeding a shared platform called Contrail. A newer "DOT mode" reframes flood severity around road classification rather than land area: minor severity means flooding affects a secondary road, moderate means it affects a state or U.S. route, and "purple" means it impacts an interstate, a threshold the team has taken to calling out loud whenever it appears.



T-SAPP, NCDOT's storm-surge tool, runs in partnership with the University of North Carolina at Chapel Hill's supercomputing center, producing surge-impact mapping across 11,000 miles of coastal roadway within two hours of each National Hurricane Center advisory.



Bridgewatch, an internal real-time alert tool, monitors more than 16,000 bridges and culverts against flood gauge data and now feeds directly into NCDOT's public traveler information system, so drivers, not just internal staff, see when flooding affects a structure. NCDOT has also begun deploying tethered drones to validate gauge readings and monitor traffic in real time, an effort that started as a modest pilot with the State Highway Patrol and has already proven its value confirming overtopping conditions during storms.



Hurricane Helene, in September 2024, tested every one of these tools at once. NCDOT described the storm as a 500-year rain event; Helene destroyed sections of Interstate 26 and Interstate 40 at the Tennessee state line, closed more than 1,400 roads across western North Carolina, killed 106 people, caused an estimated \$60 billion in damage, and knocked out communications for more than a million residents, making it the costliest and deadliest disaster in the state's history. NCDOT leaned on Bridgewatch to track rising water and on FIMAN's transportation layer to flag stretches of highway, including sections of I-40 and I-240, that had never flooded before. In the storm's aftermath, the state legislature approved significant new funding for message boards, pre-positioned portable cameras, an expanded flood gauge network, and rapidly deployable communication trailers capable of restoring cell and satellite coverage to an entire building. NCDOT frames that investment around a simple lesson: the department made do during Helene and does not intend to do the same again.

The session's discussion turned to what the field still lacks. Ciaramitaro floated embedding a National Weather Service liaison directly within NCDOT's operations center; Cavazos pointed to inaccurate flood prediction during recent Texas Hill Country flooding as evidence that forecasting itself needs more investment; Golembesky noted North Carolina has only 55 River Forecast Center gauges statewide and does not yet trust the National Weather Service's National Water Model enough to base decisions on it. An audience member pointed out that no federally supported national baseline of hazard data, LIDAR chief among them, exists to help less-resourced states and agencies, contrasting North Carolina's centralized statewide buildout with a more fragmented, MPO-by-MPO approach she has observed in Florida. Ciaramitaro acknowledged the deeper tension underneath all of it: even where hazard data is strong, designing infrastructure to the recommended 500-year or 1,000-year storm standard is expensive, and agencies often quietly downgrade to a 50-year or 10-year design standard simply to afford more projects. Golembesky added that North Carolina's statewide project-scoring process does not currently account for resilience at all: a resilience investment simply raises a project's cost and pushes it down the priority list, with no accepted way yet to translate resilience into cost avoidance that would offset that penalty.

Session 5 – Roundtable Discussion on Resiliency Challenges and Opportunities

Matt Hardy of ITE moderated the day's closing roundtable. Hardy opened with his own synthesis of the day's recurring threads:

- The need for hardware investment paired with better data and software
- The challenge of turning raw data into decisions people can act on, citing Maryland's RITIS platform and North Carolina's flood tools as examples that already do this well
- The importance of rehearsed interagency coordination
- A reframing of "extreme weather" as simply the new baseline rather than an exception
- Aging infrastructure, both physical assets and the sensor layer monitoring them, as an asset-management challenge in its own right
- The difficulty of communicating the "soft costs" of disruption, such as lost travel time and delayed freight, in terms that move decision-makers to act

Several participants raised additional topics the day's formal sessions had not covered:

- Dave Adams of PennDOT named copper wire theft as a growing maintenance headache in the Philadelphia area, with a long-term shift to aluminum wiring as the only real fix.
- Nicholas Ramfos raised underground infrastructure strikes, utility and fiber lines damaged during DOT work zones, sometimes with injuries or fatalities, as a topic better suited to NOCoE's planned follow-up webinar on man-made resilience threats.
- Kurt Golembesky of NCDOT proposed folding resilience data directly into *Transportation Asset Management Plans*. This can be supported by using Bridgework's overtopping records to trigger more frequent inspections at chronically affected bridges, an idea Sean Flaherty of HDR endorsed as a natural next phase for risk and vulnerability assessments generally. Flaherty noted that climate-data access is a challenge across his firm's clients, public and private alike, including freight railroads.
- Skye Guo, of the District Department of Transportation, described a fiber outage from a microburst the night before the peer exchange that knocked out DDOT's Route 295 network and required an ITS engineer's help to restore. A small, but timely example of the technical knowledge gaps several participants raised throughout the day.
- Guo also raised a harder problem: DDOT's mayor is relocating the agency's primary Traffic Management Center, and while leadership wants to build a secondary facility in its place, DDOT does not yet know how much redundancy it needs, and funding a second TMC competes directly against routine maintenance budgets. She asked the group directly for examples of what peer agencies have built for backup TMCs and what they cost.
- Jason Dicembre of Maryland SHA argued for clearer, resilience-specific performance metrics: a corridor that becomes less reliable after a disruption is not necessarily less resilient, but without the right metrics agencies cannot tell the difference.
- Dom Ciaramitaro of NCDOT proposed extending the state's FIMAN-style flood gauge network across state lines into Virginia, South Carolina, and Tennessee.

The live polling that followed surfaced funding as the single most common answer to the day's biggest challenge, echoed across nearly every topic area. Additionally, participants listed difficulty accessing climate data and technology-knowledge gaps.

Participants saw the clearest opportunities as:

- Learning directly from peers
- Tying operations funding explicitly to resilience outcomes
- Applying emerging tools such as artificial intelligence to real-time signal optimization and event prediction.

On what skills the field lacks, participants named nature-based solutions expertise, which Flaherty noted remains a niche practice despite frequent discussion, along with the soft skills to communicate resilience value to non-technical audiences.

On what knowledge most needs sharing, Hardy proposed a standardized case-study format modeled directly on the day's own presentations, and Guo's request for secondary TMC examples surfaced again as a concrete, specific ask.

Closing out the poll, participants named the added cost of designing in resilience and the need to more clearly distinguish infrastructure resilience from operational resilience as open research questions the field has yet to resolve.

Key Learnings and Next Steps

Nicholas Ramfos closed the day by naming the themes he heard recur most across the sessions:

- The persistent gap in documenting resilience benefits
- The lack of a shared, common definition of resilience itself
- The still-unresolved connection between cybersecurity and resilience
- The case for dedicated resiliency manager roles as a workforce investment
- The absence of resilience from long-range planning, STIP scoring, and MPO project selection
- The need for more River Forecast Center gauge coverage nationally
- The value of case studies and shared best practices
- The importance of prioritizing structures by traffic and freight impact
- The opportunity in cross-state coordination on shared monitoring networks.

Several threads ran across multiple sessions. Presenters throughout the day were careful to separate resilience from reliability: a system that becomes temporarily less reliable after a disruption is not necessarily less resilient, and the field needs performance metrics built specifically to make that distinction.

Funding scarcity surfaced independently in nearly every session: Hawaii DOT, Wilmington MPO, TRPA, San Antonio River Authority, and NCDOT all named it and returned as the top response in the roundtable's live poll. The PROTECT program is the funding vehicle most agencies are already using or pursuing, though not always successfully. Resilience still has no foothold in the formal process's agencies use to decide which projects to build. Both the Wilmington MPO and NCDOT described prioritization and scoring formulas that simply treat resilience investments as added cost, with no accepted way yet to translate resilience into the kind of cost-avoidance figure that would offset that penalty. Hawaii DOT and Florida DOT both named the same organizational gap: no dedicated resiliency manager, which was something Ramfos echoed in his closing remarks as a workforce issue NOCoE should track.

Two sessions in particular showed how far monitoring networks have come, and how far they still have to go: NCDOT's flood-warning tools have scaled from roughly 50 flood gauges to more than 780 since Tropical Storm Debby proved their value, while San Antonio River Authority's newer countywide flood analysis has

already identified far more at-risk roads than its 200-sensor network can realistically cover. That gap between what agencies now know and what they can afford to monitor is likely to recur elsewhere.

The Key Bridge and I-95 Cottman Avenue responses both showed that frontline, operator-level relationships matter as much as relationships between agency leadership, and that both had quietly eroded in ways their agencies only discovered under pressure.

Both Maryland and Pennsylvania also found that tools and equipment built for crisis response — RITIS, INRIX, StreetLight Data, portable cameras went on to serve planned events including World Cup preparations.

And, in both cases, unexpected partners proved essential: the Eastern Transportation Coalition's outreach on Waze routing, and city police managing local detours directly.

Finally, while this peer exchange deliberately set aside man-made and cyber resilience threats, Ramfos confirmed a follow-up webinar to take up that ground, including the underground infrastructure strikes he raised himself during the roundtable.

Next Steps

NOCoe will continue coordinating with ITE's Resiliency Great Ideas Group as it carries out its own action plan of case studies, technical briefs, and conference sessions. Beyond the confirmed follow-up webinar on man-made resilience threats, several product ideas emerged directly from the day's discussion:

- A standardized case-study format modeled on this event's presentations, building on the Florida DOT and North Carolina DOT case studies already underway through ITE
- Guidance connecting resilience-specific performance metrics to the reliability metrics agencies already track
- A synthesis of how states are, or are not, scoring resilience into project-prioritization and STIP processes
- A resource compilation on flood and hazard monitoring network buildouts drawing on NCDOT's and San Antonio River Authority's experience.

Several organizations offer natural next stops for attendees who want to go deeper:

1. ITE's Resiliency Great Ideas Group remains the clearest point of coordination, reachable through Matt Hardy
2. The PROTECT program under the Infrastructure Investment and Jobs Act is the primary federal funding vehicle multiple agencies are already using or pursuing
3. National Weather Service and NOAA are the obvious partners on the embedded-liaison, gauge-refresh-rate, and River Forecast Center gaps participants raised throughout the day

Several presenters left the door open for direct follow-up:

- NCDOT is open to discussing cross-state expansion of its gauge network into Virginia, South Carolina, and Tennessee.
- San Antonio River Authority continues working with Apple to become a recognized authoritative source for road closures
- TRPA's data-procurement RFP is still open as it builds out its Resilience Improvement Plan.

Resources

ITE

- [ITE Transportation Resilience Great Ideas Group](#) – contact Matt Hardy, mhardy@ite.org
- [ITE Journal, October 2024 \(Vol. 97, No. 10\)](#) – resilience issue
- [NOCoe case study library](#) – including NCDOT's [Statewide ITS Resiliency Project](#)

Federal

- [PROTECT Formula Program \(FHWA\)](#) – Infrastructure Investment and Jobs Act, [23 U.S.C. § 176](#)
- [FEMA Flood Map Service Center](#) and the [National Flood Hazard Layer](#) – water-surface-elevation data used in flood-risk analysis
- [USGS National Water Dashboard](#) and the [Groundwater and Streamflow Information Program](#) – stream gauge data
- [National Hurricane Center](#) – [active cyclones and advisories](#)
- [National Weather Service River Forecast Centers](#)

Tools and Platforms

- [RITIS \(CATT Lab, University of Maryland\)](#) – regional signal and traffic analytics
- [INRIX](#) and [StreetLight Data](#) – travel-time and origin-destination analytics
- [FIMAN \(Flood Inundation Mapping and Alert Network\)](#) and [the Contrail platform, now AEM Elements 360](#) – NCDOT
- [T-SAPP \(Transportation Surge Analysis Prediction Program\)](#) – NCDOT, built with UNC Chapel Hill
- [BridgeWatch, within the NCDOT Flood Warning System](#) – real-time bridge and culvert flood alerts

Agency and Project Resources

- [Hawaii DOT Resilience](#) – Resilience Improvement Plan in development
- [Wilmington Urban Area MPO plans](#) – ITS Plan Update (2025) and Resilience Improvement Plan (beginning state fiscal year 2027)
- [Florida DOT District 4 TSMO Program](#) – TSMO Master Plan
- [Maryland Key Bridge news and response](#) and the [Key Bridge Rebuild project site](#)
- [PennDOT District 6 I-95 Cottman Avenue recovery](#)
- [Tahoe Regional Planning Agency Transportation](#) – Resilience Improvement Plan and Regional Emergency Communications and Transportation Strategy
- [SARiverFlood.org](#) – San Antonio River Authority flood monitoring and text alerts; background at [Reduce Flood Risk](#); Bexar County companion site [BexarFlood.org](#)
- [NOCoe newsletter](#)
- [NOCoe video library](#)

Appendix A – Agenda

Time (ET)	Session	Speakers
11:00 – 11:10 am	NOCoE Welcome	Nicholas Ramfos, NOCoE
11:10 – 11:30 am	Briefing on ITE Resiliency Great Ideas Group	Matt Hardy, ITE; Aimee Flannery, Jacobs
11:30 am – 12:30 pm	Resiliency Planning Use Cases (Moderator: Sean Flaherty, HDR)	Landon Kaya, Hawaii DOT; Abby Lorenzo, Wilmington MPO; Alexandra Lopez, Florida DOT
12:30 – 1:30 pm	Operational Resilience: Coordinating Across Infrastructure Failures (Moderator: Beverly Kuhn, C-DEX Advisors)	Jason Dicembre, MD SHA; Jason Pulliam, MDTA; Dave Adams, PennDOT
1:30 – 1:45 pm	Break	—
1:45 – 2:45 pm	Resiliency for Extreme Weather (Moderator: Aimee Flannery, Jacobs)	Rachael Shaw, TRPA; Erin Cavazos, San Antonio River Authority; Dom Ciaramitaro and Kurt Golembesky, NCDOT
2:45 – 3:45 pm	Roundtable Discussion on Resiliency Challenges and Opportunities (Moderator: Matt Hardy, ITE)	All attendees
3:45 – 4:00 pm	Key Learnings and Next Steps	Nicholas Ramfos, NOCoE