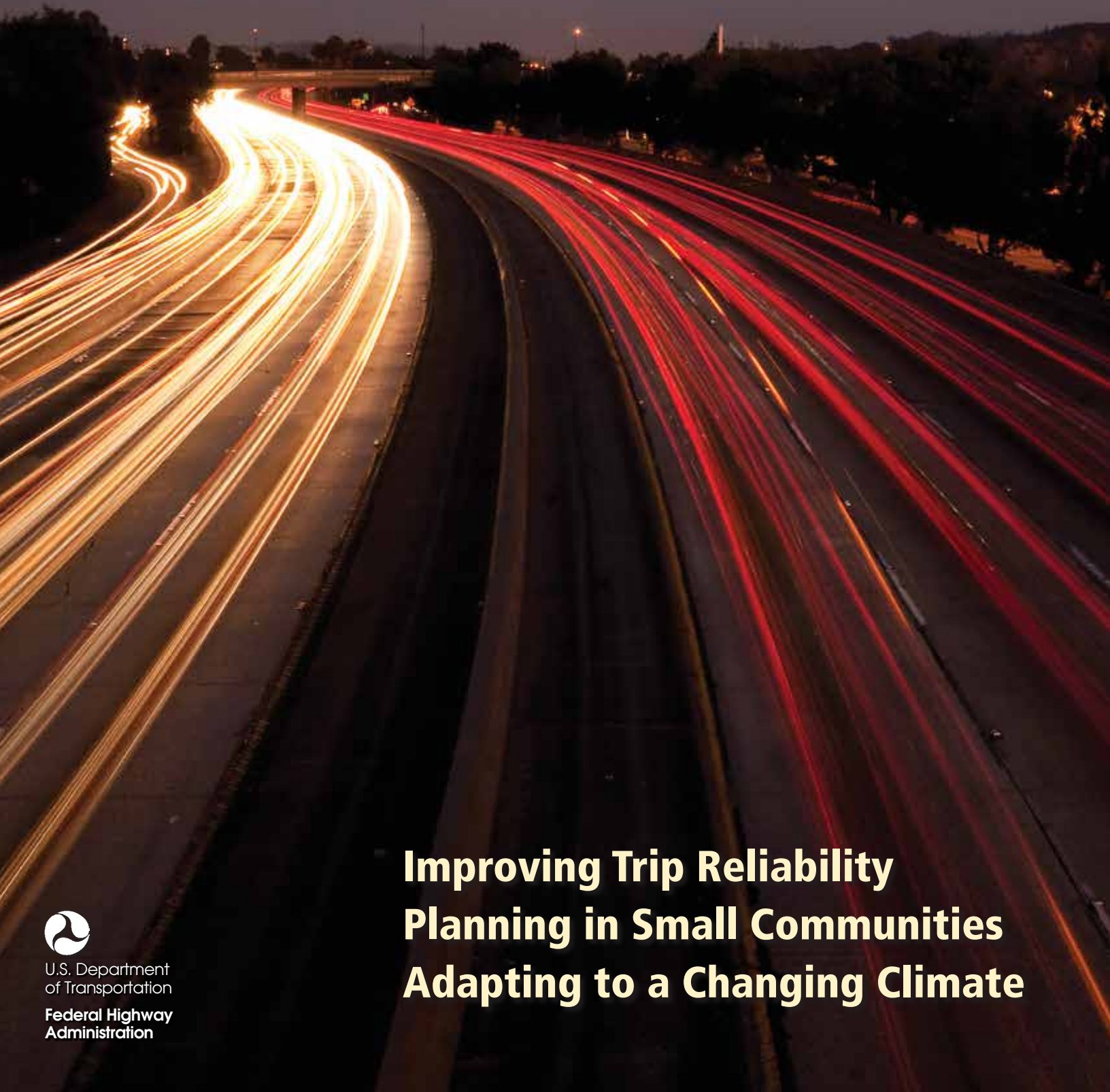


Public Roads

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November/December 2014



**Improving Trip Reliability
Planning in Small Communities
Adapting to a Changing Climate**



U.S. Department
of Transportation
Federal Highway
Administration

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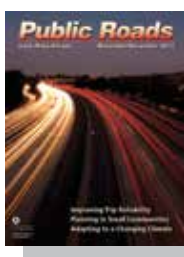
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Front cover—This long-exposure photograph depicts the smooth flow of automobile traffic on a highway in Los Angeles, CA. The second Strategic Highway Research Program's (SHRP2) Organizing for Reliability Tools helps transportation agencies make changes in their organization and business processes that improve their systems management and operations and help keep traffic moving. For more information, see "A New Approach to Improving Travel Times" on page 2 in this issue of PUBLIC ROADS. *Photo: ©iStockphoto.com/jamesdvdsn.*

Back cover—Even with the best of planning, unexpected delays can sometimes occur in work zones like this one on I-85 in North Carolina. SHRP2 has developed tools to improve the analysis of nonrecurring congestion and travel time reliability to help identify trouble spots. Solutions like Organizing for Reliability Tools help agencies collaborate to increase safety and mobility. For more information, see "A New Approach to Improving Travel Times" on page 2 in this issue of PUBLIC ROADS. *Photo: FHWA.*



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Guest Editorial

Innovation in Environment and Planning

Ask a passerby on the street what "innovation" means, and you might hear a reply that amounts to something like this: "a significant improvement in a product, industrial process, or construction technique." In many cases, including within the transportation industry, this response rings true. Just look at the innovations catalogued on the Federal Highway Administration's (FHWA) Every Day Counts Web site. There you will find descriptions of such innovations as warm-mix asphalt, design-build contracting, and slide-in bridge construction.

But many aspects of FHWA's business, specifically in planning and environmental protection, exhibit less conventional innovations that carry equal importance for improving the quality, cost effectiveness, and speed of delivering transportation projects. For example, this issue of *PUBLIC ROADS* spotlights tools developed to help communities cope with weather-related events, account for climate change risks, and plan for resiliency to future environmental conditions.

One example is the Gulf Coast Study, which identified climate change vulnerabilities and developed adaptation options for key transportation facilities. FHWA manages the study on behalf of the U.S. Department of Transportation in partnership with the U.S. Geological Survey. The lessons learned will be applicable across the country. Also, pilot projects on resiliency to climate change led to development of FHWA's new *Climate Change & Extreme Weather Vulnerability Assessment Framework* (FHWA-HEP-13-005), which will help communities everywhere evaluate their level of risk.

Also spotlighted in this issue are innovative tools that can help smaller communities with limited staffing and budgets better plan for transportation investments. Among them are techniques to use data collected from cell phones to conduct travel surveys and use of Web-based GIS tools for data visualization to improve public participation.

In another planning and environmental innovation, FHWA recently launched e-NEPA, a secure online tool for collaboration and project development that facilitates concurrent intra- and inter-agency reviews of environmental impact statements. This tool tracks comments, schedules tasks, and saves paper—ultimately, accelerating project delivery.

In a similar vein, FHWA is establishing programmatic consultations across entire



wildlife ranges to streamline compliance with the Endangered Species Act. One example is a programmatic consultation for the northern long-eared bat, covering 39 States. Other consultations focus on sturgeons, sea turtles, and essential fish habitats along the Atlantic coast. Undertaken with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, programmatic consultations build consistency, accelerate project delivery, and improve species conservation.

In a planning innovation under the Strategic Highway Research Program 2, FHWA is working to integrate economic, environmental, and community needs into transportation planning and project development. For example, "PlanWorks: Better planning. Better projects." is an upcoming Web resource supporting improved collaboration to help diagnose barriers and develop strategies to overcome them. Similarly, FHWA's "PlaceFit" tool compiles information to help planners compare factors on jobs, recreation, education, health care, commuting options, pedestrian and bicycle networks, and other needs to achieve more livable communities.

Delivering transportation improvements involves many steps from long-range planning to project financing and development to construction and operation. FHWA is helping States and communities deliver their transportation programs through innovations that improve collaboration in the planning process, provide better information for decisionmaking, and accelerate project delivery.

Gloria M. Shepherd

Gloria M. Shepherd
Associate Administrator
FHWA Office of Planning,
Environment, and Realty



A suite of tools developed under SHRP2 is helping transportation agencies institutionalize systems management and operations with the goal of reducing congestion and increasing safety and reliability.

A New Approach to Improving Travel Times

by Joe Gregory and Ben Irwin

(Above) Reducing bumper-to-bumper traffic like this and improving travel time reliability are among the goals of a major push to formalize transportation systems management and operations programs nationwide. Photo: iStock.

Congestion is a persistent problem on U.S. highways, stealing an average of 38 hours a year from commuters. Snarled traffic not only increases travel times but also has an adverse effect on motorists' safety and costs to travelers and businesses. Facing this challenge with increasingly constrained resources, State and local transportation agencies are looking beyond traditional methods of adding capacity, such as more lanes, and exploring a concept known as transportation systems management and operations (TSM&O) to increase mobility.

As defined in the Moving Ahead for Progress in the 21st Century Act, TSM&O means "integrated strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system."

Examples of integrated operations-related strategies and solutions already at work to maximize the capacity of existing infrastructure include dynamic speed limits, adaptive ramp metering, real-time traveler information, and traffic signal coordination. The transportation industry's increased reliance on information and technology, especially intelligent transportation systems (ITS), supports the move

toward systems management and operations. Although this approach addresses congestion with more efficient and less invasive solutions than constructing new roads, most transportation agencies lack a formal strategy or program for TSM&O.

That is where the second Strategic Highway Research Program (SHRP2) comes in. A partnership among the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB), SHRP2 exists to accelerate implementation of proven transportation solutions to save lives, money, and time. The SHRP2 program of research, development, and deployment is organized into four focus areas: safety, renewal, reliability, and capacity.

One of the SHRP2 solutions is called Organizing for Reliability Tools and consists of several components designed to advance systems management and operations. The first is a set of case studies and guidance to help transportation agencies integrate and improve business processes related to operations, such as planning, budgeting, programming, and procurement. The second is a self-assessment guide accessible online or via facilitated in-person workshops that helps practitioners evaluate their agency's institutional and process-oriented capabilities in systems management and operations and create an action plan to systematically improve those capabilities. The latest tool is a customizable slideshow presentation that targets middle- to senior-level transportation executives.

Use of the Organizing for Reliability Tools can lead to improved performance of the highway system, greater reliability in travel times, and enhanced safety. Agencies across the country now are taking steps to implement this SHRP2 solution and transform their operations to improve mobility for motorists and freight.

Many States use ITS technologies, like this dynamic message sign above I-40 in Tennessee, to communicate critical information to motorists, which can help reduce congestion.

SHRP2 SOLUTIONS

TOOLS FOR THE ROAD AHEAD

Rising Costs and Expectations

A product to help States grow their capabilities in transportation systems management and operations could not have come at a better time, given the high cost and changing public perceptions regarding congestion. For example, in 2011, congestion in 497 metropolitan areas caused urban motorists to endure 5.5 billion more hours traveling to their destinations and purchase an extra 2.9 billion gallons of fuel, all at a cost of \$121 billion. Perhaps more important than the direct costs are the secondary costs of frustration, missed appointments, and late deliveries due to nonrecurring or unexpected events such as traffic incidents, construction zones, special events, and inclement weather that increase travel times.

More than half of all congestion (urban and rural) is the result of nonrecurring events, which adversely affect the predictability of the travel times that motorists can expect for a given trip, otherwise known as travel time reliability. Further, nonrecurring

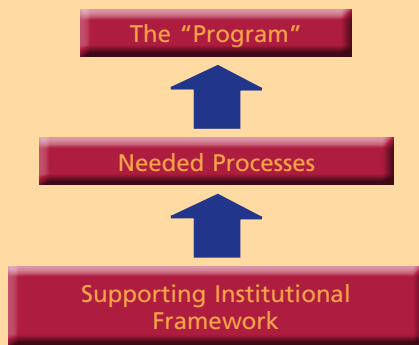
congestion increases safety risks to travelers and those who encounter and respond to those events. In fact, approximately 20 percent of all traffic incidents are secondary incidents—crashes, mechanical problems, and running out of fuel—that occur as a result of congestion associated with a prior incident. These secondary incidents further increase congestion, putting additional travelers and responders in harm's way.

At the same time, driver expectations are evolving. Although motorists can plan for and tolerate a certain amount of recurring congestion, both commuters and shippers are less tolerant of nonrecurring congestion. For one thing, this kind of congestion is difficult to plan for and thus affects personal and commercial schedules in unexpected ways.

In the past, transportation agencies addressed congestion by building more lanes and roads. Today, however, with financial constraints on design, construction, and acquiring additional rights-of-way, transportation officials find it challenging to secure approval for projects to add



Capability Maturity Model



- What are the characteristics of an effective TSM&O program?
- What business and technical processes are needed?
- What kind of organization and relationships support the process?

This underlying organizational framework helps an agency identify the needed processes that ultimately help grow its TSM&O capabilities into a formal program. Source: FHWA.

lane miles. Therefore, strategies for transportation system management and operations that maximize the use of existing capacity are critical to addressing the congestion problem.

From Research Toward a Solution

The SHRP2 solution known as Organizing for Reliability Tools grew out of a research project designed to identify and examine the critical relationships, business processes, and organizational structures that lead to successful systems management and improved travel time reliability. As part of this effort, researchers at TRB surveyed 22 State departments of transportation (DOTs) found to have mature or emerging systems management and operations functions.

The research found that the most important factors in having effective systems management and operations were not the result of using particular technologies or strategies. Instead, improved TSM&O requires systematic improvements to an agency's business and technical processes and institutional framework, as well as a formal program to improve over time. This requires a significant shift in priorities for agencies that traditionally have focused on core programs such as construction and maintenance.

Systematic Implementation

To help agencies make this systematic change, experts at TRB worked together with a consultant team to design a set of resources packaged

under the SHRP2 solution called Organizing for Reliability Tools. The solution includes an online assessment and guidance tool, as well as a guidebook for improving TSM&O capabilities, a series of case studies, and an executive presentation and guide, all published by TRB.

The core of Organizing for Reliability Tools is the Capability Maturity Model, a management tool designed to guide improvement of TSM&O over time. The model combines into a single framework the key features of quality management, organizational development, and business process reengineering that transportation agencies have long used as strategic management tools. The model is described in detail in the TRB publication *Institutional Architectures to Improve Systems Operations and Management* (Report S2-L06-RR-1) and currently

is available on AASHTO's Web site at www.aashtotsmoguidance.org.

To expedite adoption of the model and its framework, FHWA offers a self-assessment workshop for practitioners. The workshop is a facilitated interactive discussion among transportation agency executives, managers, staff members, and key partners to assess their capabilities related to TSM&O.

"FHWA is committed to providing this innovative tool to State and local agencies," says FHWA Associate Administrator for Operations Jeffrey Lindley. "The Capability Maturity Model framework is a proven tool to help practitioners assess their own capabilities and develop a roadmap for how they can most effectively improve the mobility and reliability of their transportation system."

The capability assessment workshops bring together staff members from across an agency and its partners, often for the first time, to discuss how they coordinate internally and in partnership. They look closely at how they can reorganize their agencies to better operate the transportation facilities they have in place. Attendees identify opportunities to advance the processes and institutional culture of their organization to improve operations.

"[The workshop] guides agencies to look beyond the traditional engineering solutions and into areas that are often neglected, such as business processes, culture, and relationships," Lindley says. "By asking very targeted questions, it encourages agencies to break down silos and engage internal and external partners to enhance the efficiency with

Levels in the Capability Maturity Model



Source: FHWA.

which existing services are delivered. Organizing for Reliability Tools helps agencies take a more proactive approach to operating the system.”

Description of the Model

SHRP2 research identified six interdependent dimensions, or capabilities, that are most important in determining successful execution of systems management and operations. The dimensions are as follows:

- **Business processes** describe the level to which TSM&O is integrated into State and regional planning processes, programming, and budgeting.
- **Systems and technology** describe an agency’s ability to use, standardize, and improve systems and technology that support TSM&O.
- **Performance measurement** captures an agency’s ability to acquire, analyze, and use information about system and operational performance effectively.
- **Culture** examines the knowledge, leadership support, and authority an agency commits to TSM&O.
- **Organization/workforce** captures the level to which an agency possesses the staff capabilities and organizational structure to support TSM&O.
- **Collaboration** with local and regional partners is a key factor in an agency’s success implementing TSM&O.

During the self-assessment process, conducted during the FHWA workshop or as part of the online tool, an agency examines a variety of factors affecting each dimension. That examination leads the group to assign one of the following four progressive levels of capability maturity for each dimension.

1. **Performed.** Agency TSM&O activities and relationships are largely ad hoc, informal, and champion driven.
2. **Managed.** Agency is developing processes and training staff, but there is limited accountability for TSM&O.
3. **Integrated.** Agency is nearing a formal program with documented processes, performance measures, and budget.
4. **Optimized.** A formal program exists with continual improvement and formal partnerships.

The first three levels describe observable activities that demon-

Dimension	Level 1	Level 2	Level 3	Level 4
Business Processes (Planning, programming, budgeting, implementation)	✓ Processes related to TSM&O activities ad hoc and unintegrated	Multiyear statewide TSM&O plan and program exists with deficiencies, evaluation, and strategies	Programming, budgeting, and project development processes for TSM&O standardized and documented	Processes streamlined and subject to continuous improvement
Systems & Technology (Systems engineering, standards, and technology interoperability)	Ad hoc approaches outside systematic systems engineering	✓ Systems engineering employed and consistently used for concept of operations, architecture, and systems development	Systems and technology standardized, documented, and trained statewide, and new technology incorporated	Systems and technology routinely upgraded and utilized to improve efficiency performance
Performance Measurement (Measures, data and analytics, and utilization)	No regular performance measurement related to TSM&O	✓ TSM&O strategies measurement is largely via outputs, with limited after-action analyses	Outcome measures identified and consistently used for TSM&O strategies improvement	Mission-related outputs/outcomes data routinely utilized for management, reported internally and externally, and archived
Culture (Technical understanding, leadership, outreach, and program authority)	✓ Value of TSM&O not widely understood beyond champions	Agencywide appreciation of the value and role of TSM&O	TSM&O accepted as a formal core program	Explicit agency commitment to TSM&O as key strategy to achieve full range of mobility, safety, and livability/ sustainability objectives

Through AASHTO’s One-Minute Guidance Evaluation, practitioners can quickly decide which level of maturity best applies to their agency or region for each dimension. In this example from the self-assessment tool showing four of the six dimensions, a practitioner has selected the maturity levels shown in the blue shaded boxes. Source: www.aashtotsmoguidance.org.

strate increasing integration of TSM&O practices within the agency. The fourth level describes the ideal for how the agency would function within the given dimension. The end result of this process is a Capability Maturity Model matrix that includes all six dimensions and the existing level of maturity for each, as determined by the agency and its partners. With the matrix in hand, an agency can develop a tactical plan for systematically improving each dimension. An agency then can use the other Organizing for Reliability Tools, as well as other SHRP2 and TSM&O resources, to support improvement efforts.

A key concept to Organizing for Reliability Tools involves recognizing that each dimension of the model matrix is essential and dependent on the others. Therefore, dimensions at the lowest level of

capability must improve first. For example, an agency will struggle to move forward in other dimensions if its culture remains at level 1 and is lagging behind.

Implementation Assistance

To help State DOTs and metropolitan planning organizations (MPOs) deploy SHRP2 Solutions, including the Organizing for Reliability Tools, FHWA and AASHTO created the SHRP2 Implementation Assistance Program.

The 27 lead adopters in systems management and operations that were selected to receive support through the assistance program are developing implementation plans based on the assessments generated using the Capability Maturity Model. These plans will identify priorities and actions that agencies intend to implement over



Since holding a TSM&O workshop in 2009, the Tennessee Department of Transportation has created a Traffic Operations Division, which uses cameras like this one to monitor traffic flow on its highways.

the next few years, with SHRP2 assistance focused on 2014–2016 to advance their capabilities.

During the implementation phase, FHWA and AASHTO will provide technical and financial support to the lead adopters targeted to their needs and priorities. This support might include the following:

- *Training* to increase staff proficiency in a range of technical and organizational topics and to nurture and grow new operations champions.
- *Workshops and working meetings* to bring together professional staff to advance specific activities of the action plan.
- *Peer exchanges* (in person and virtual) to expose staff to new ideas and concepts and share experiences with State and local peers.
- *Technical assistance* to advance programmatic and project priorities to achieve the outcomes defined in the action plan.
- *Collaboration* with local partners and nationally, building on the strong organizational framework of AASHTO's subcommittees to foster the successful transformation of organizations to advance operations.
- *Tactical assessments* consisting of indepth reviews of current processes associated with one or more dimensions to identify possible enhancements.
- *Followup briefings* for senior agency leaders to help sustain momentum.

This 2-year endeavor is part of an ongoing process to fully mainstream operations into the institutional and organizational framework

of every State DOT and MPO in the country.

"We envision that the lead adopters will become champions for the power and value of Organizing for Reliability Tools, serving as advocates to share the tools with their peers," says Steve Clinger, operations deployment team leader in the FHWA Office of Operations. "In this way the SHRP2 products will be brought from the confines of reports and PowerPoint® presentations into widespread adoption and daily use—and continue to be applied long after the SHRP2 effort has been completed."

Modeling in the Field

Already, more than 35 transportation agencies—including State DOTs, MPOs, and regional or corridor coalitions—are using the Capability Maturity Model framework and related tools to help improve TSM&O and the reliability of their highway systems. This includes agencies participating in the assistance program, as well as earlier pilot sites and a few additional organizations that heard about the tools and decided to put them to use.

What follows are descriptions of how several agencies have used the framework and what they plan to do next.

Tennessee Department Of Transportation

The I-24 corridor between Nashville and Murfreesboro is near one of the fastest growing metropolitan areas in the Nation. Officials with the Tennessee Department of Transportation (TDOT), therefore, understand the importance of

maximizing highway capacity and safety, and achieving more reliable travel times for motorists. In fact, TDOT was among the first agencies in the country to participate in a workshop on the Capability Maturity Model back in 2009.

Brad Freeze, director of TDOT's Traffic Operations Division, recalls systems management and operations before the workshop. "Before 2009, TSM&O leadership was a bit disjointed because responsibilities were spread across different divisions," he says. "Our Intelligent Transportation Systems Design Office took the lead, creating a coordinating committee that championed ITS and our highway incident management program. However, there were few standardized processes and procedures across operations."

Since the workshop, TDOT has taken steps to move its TSM&O capabilities from a performed state of maturity (level 1) to the managed and integrated states (levels 2 and 3). For example, it organized a Traffic Operations Division, which was established in January 2013. "Now we have a division that can take the lead in systems management and operations," Freeze says, "not just champion it."

TDOT was awarded assistance from the SHRP2 Implementation Assistance Program, which is helping the agency further improve the dimensions of success within its systems management and operations. TDOT updated its self-assessment through a subsequent Capability Maturity Model workshop, and the resulting implementation plan includes action items such as providing technical training for staff, upgrading ITS design and deployment, developing an asset management plan, and creating a dedicated TSM&O committee. The assessment process also reinforced the importance of performance measurement for TDOT. In July 2014, TDOT participated in a peer exchange with the Washington State Department of Transportation and its partners to learn about their use of performance measurement tools and reports that provide data to both the department and travelers alike.

Says Freeze, "We are refining performance measures, such as travel time reliability and average annual delay, and how we can provide

useful information to people using the roads. Now we have momentum and support from the top down, and we are pushing the limits on what we can do, such as ramp metering and dynamic speed control.”

Northeast Ohio Areawide Coordinating Agency

According to Josh Naramore, transportation studies manager for the Northeast Ohio Areawide Coordinating Agency, Cleveland’s MPO, his agency has always been interested in systems management and operations. “The organization’s projects were largely related to signal systems projects and incident management trainings, but the response was mostly ad hoc,” he says. “We had engineers who had done that work before, but we were not really leading it. We were waiting for projects to come to us.”

However, when planning began for the new I-90 Innerbelt Modernization project in Cuyahoga County, the agency took a more active approach, partnering with the Ohio Department of Transportation, Cuyahoga County, and the Greater Cleveland Regional Transit Authority to maximize improvements to enhance safety and reduce congestion. The agency received SHRP2 implementation assistance from FHWA to explore ways to maintain travel time reliability on the new facility, as well as during several other planned construction projects. The technical assistance included help in developing an implementation plan, providing peer reviews, and delivering trainings, such as a self-assessment workshop held in January 2014 focused on the Capability Maturity Model.

The agency invited to the workshop a broad cross section of partners, ranging from emergency response personnel to tow truck operators to city/county traffic

engineers. Representatives from the largest cities and all of the related counties also attended.

“This was an opportunity to pull back and look beyond individual construction projects to find something broader,” Naramore says, “to ask how we can improve our regional approach [to systems management] and get buy-in from key partners.”

The workshop provided a detailed understanding of the region’s strengths and weaknesses in systems management and operations across the six dimensions and helped identify action items. Among the action items were developing a best practices toolkit for systems engineering (to improve the systems and technology dimension) and identifying and compiling necessary data and information for a strong TSM&O business case (to improve the culture dimension).

What’s next? The agency now has a draft implementation plan that includes actionable steps that will help the region improve across the board. “We want to build organizational structures, such as a safety and operations advisory council, that formalize the conversations that resulted from the workshop and provide a forum to share more ideas,” Naramore says. The agency also is developing a scope of work to fund the creation of 5- to 10-year strategic plans for operations, including traveler information, performance measurement, and priority projects.

“We want to focus on understanding where we should be targeting our resources and what our approach should be regarding interoperability and streamlining of technologies,” he says. “We want to start tying everything together.”

North Central Texas Council of Governments

Similar to the previous examples from Tennessee and Ohio, at the North Central Texas Council of Governments, systems management and operations were largely ad hoc prior to conducting a capability assessment workshop in August 2012. “A good thing within our region is that we already had a lot of collaboration,” says Natalie Bettger, the council’s senior program manager for congestion management and system operation. “But the workshop allowed us to focus that collaboration.”

With improving collaboration in mind, the council invited a large cross section of partners to the workshop, including the Texas Department of Transportation, the regional toll authority, local transit agencies, a number of city transportation departments, and private partners such as public-private partnership concessionaires. “It brought us all to the table to talk about where we are as a region and what our systems management and operations processes should be,” she says.

Consistent with the Capability Maturity Model process, the council now has a list of action items to

A workshop hosted by the North Central Texas Council of Governments discussed delegation of responsibilities during responses to crashes, weather, and other events that affect the region’s roadways. Here, an officer with the Texas Department of Transportation responds to a traffic incident on I-45 in Dallas.



North Central Texas Council of Governments

help the region focus on improving its capabilities. “Each action item has lead coordinating agencies, and we meet to update the status of the list every 6 months,” says Bettger.

The council continues to address action items that resulted from the workshop. For example, council officials conducted a deficiency analysis of the region’s major corridors, examining freeways, frontage roads, parallel arterials, and limited-access facilities, and identifying and prioritizing opportunities to improve travel time reliability. The region also is improving incident management training based on results from the modeling effort, having recently held a regional workshop with incident managers that established a standard definition for performance measures.

Says Bettger, “We wanted to make sure everyone had a shared set of terms and could communicate effectively with each other and traffic management centers.”

North Carolina Department Of Transportation

North Carolina is a predominantly rural State that does not experience the same level of congestion as some of the more urban States. According to Jennifer Portanova, State traffic operations engineer at the North Carolina Department of Transportation (NCDOT), this means that State and local officials still approach congestion issues largely from a construction and capacity-building perspective. However, unlike many States, North Carolina has dedicated funding for systems management.

“We have been able to do a lot with that support,” Portanova says, “such as connecting planning to operations. The Capability Maturity Model process helped us define what level of maturity we were at and steps to help get us to the next level.”

NCDOT’s workshop was held in September 2011 and came at a critical period for the department. “At the same time, we just had a fresh group of people come into the department with a background in traffic management,” Portanova says. The emphasis also changed from ITS operations to traffic systems and operations with a departmental restructuring that brought arterial and freeway management into one unit. The baseline provided by the model framework enabled NCDOT to take advantage of these opportunities.

What’s more, the model framework has been a catalyst for continued growth in TSM&O in the State. NCDOT built on the workshop by developing a strategic plan for TSM&O a year later. “We were able to use that as a tool to sell TSM&O to decisionmakers,” says Portanova. “It gave us more credibility.”

As part of the plan, practitioners from different backgrounds also attended the University of Maryland’s Operations Academy™ Senior Management Program, an intensive 2-week training program focused on TSM&O. Some partners who participated in the workshop, such as law enforcement representatives, have since received additional training at the

academy and are helping advance the State’s TSM&O capabilities.

With this momentum, Portanova’s department is interested in doing more with Organizing for Reliability Tools to further demonstrate to higher level decisionmakers the need for a formal TSM&O program and how it would support the tradition that already exists in the State. “It’s a part of our culture more than we realize,” Portanova says. “For example, we have captured traffic incident data and provided this information to the public for 10 years.”

Summarizing the need for a focus on TSM&O and travel time reliability, Portanova adds, “Our highway system is a utility that we manage. Would we accept our electricity not having reliability? It’s the same concept. We manage this road utility. We should be concerned with its reliability.”

Portland Metro

When Metro, the regional governmental agency for the Portland, OR, metropolitan area, held a workshop on the Capability Maturity Model in September 2012, the region’s TSM&O plan had been in place for 2 years and partners already were moving forward with implementation. “We’ve long had great collaboration on TSM&O,” says Deena Platman, former principal transportation planner for Metro’s Regional Mobility Program, “so we came into the workshop with significant capital.”

Metro experienced immediate benefits from the process. Says Platman, “We held an executive session prior to the workshop that was reasonably well attended by managers and elected officials. This meeting and the workshop itself provided



The North Carolina Department of Transportation’s new Statewide Transportation Operations Center, located in Raleigh, monitors and manages the State’s roadway network 24 hours a day. As shown here, the analysts’ desks face a long wall upon which live video feeds from traffic cameras are projected. The new facility enables State agencies to respond to incidents, storms, and other events faster and more collaboratively.



Signals and dedicated lanes at this intersection in Portland, OR, help bicyclists and pedestrians safely and efficiently cross a roadway. Advances like these help mitigate nonrecurring congestion and demonstrate improved capabilities for TSM&O.

decisionmakers with a reminder about what TSM&O is and why it's a good investment for the region."

The workshop also formalized Metro's role as the facilitator, policy lead, and grant administrator for programmatic funding for TSM&O from the Metropolitan Transportation Improvement Program. "This had been a point of contention with several of our partner agencies, and the workshop was able to make the case for this role," says Platman. "We've also been able to increase collaboration with our primary transit agency."

Since the workshop, Metro worked with the Oregon Department of Transportation to identify 2014–2015 Surface Transportation Program funds for improving data capture and archiving via the region's portal for transportation data. Other projects include enhancing software for signal controllers and the central server to capture and transmit log data to the archive, and investing in detection and communications to capture data in key locations.

Formalizing TSM&O Nationwide

The end goal is improved transportation operations nationwide. That includes institutionalizing systems management and operations within DOT and MPO cultures and continuously measuring and improving operational performance and the business processes supporting it. Other goals include establishing sus-

tainable mechanisms for funding and growing staff capabilities in this area.

Adopting Organizing for Reliability Tools is just the first step. As with all SHRP2 Solutions, the product was not developed to be used in a vacuum. A host of other products are or will soon be available to help transportation agencies capitalize on organizational improvements in TSM&O. For example, the fourth round of the SHRP2 Implementation Assistance Program included Reliability Data and Analysis Tools, a suite of products to help transportation planners and engineers improve monitoring and analysis of operations-related data.

SHRP2 also developed a Web-based knowledge transfer system, available at www.tsmoinfo.org, to provide easy access to current and forthcoming TSM&O information, including all SHRP2 products designed to help agencies address congestion and improve travel time reliability. A presentation and presenter guidance are available to help communicate with chief executive officers and senior managers at DOTs about the value of incorporating operations as a core mission and business practice within their respective agencies. Similar materials are available for communicating with MPO leadership about incorporating TSM&O into the planning process.

FHWA, AASHTO, and TRB developed these products with a shared vision of turning transportation

systems management and operations into a standard practice across the country and realizing the safety, economic, and customer service benefits of a more efficient and reliable highway system. The Capability Maturity Model framework and other Organizing for Reliability Tools provide the foundation for this vision, empowering transportation agencies to assess their own capabilities and then take logical steps to systematically improve TSM&O within their organizations.

Joe Gregory is a program manager for the FHWA Office of Operations and manages the Organizing for Reliability initiative. He holds a bachelor's degree in civil engineering from the University of Tennessee and is a licensed professional engineer in Utah.

Ben Irwin is a senior communications specialist who works with the U.S. Department of Transportation's Volpe National Transportation Systems Center to help Federal, State, and local agencies promote transportation safety programs and innovations. He has a bachelor's degree from the University of Iowa.

For more information, visit www.fhwa.dot.gov/goshrp2/Solutions/Reliability/L06_L01_L31_L34/Organizing_for_Reliability_Tools or contact Joe Gregory at 202-366-0610 or joseph.gregory@dot.gov. See also AASHTO's "Transportation Systems Management and Operations" Web site at www.aashtotsmo.guidance.org, where you can explore 1-minute and custom guidance evaluations or browse the complete set of guidance. For more about the SHRP2 Implementation Assistance Program, which accepts applications approximately twice a year, visit www.fhwa.dot.gov/goshrp2/ImplementationAssistance.

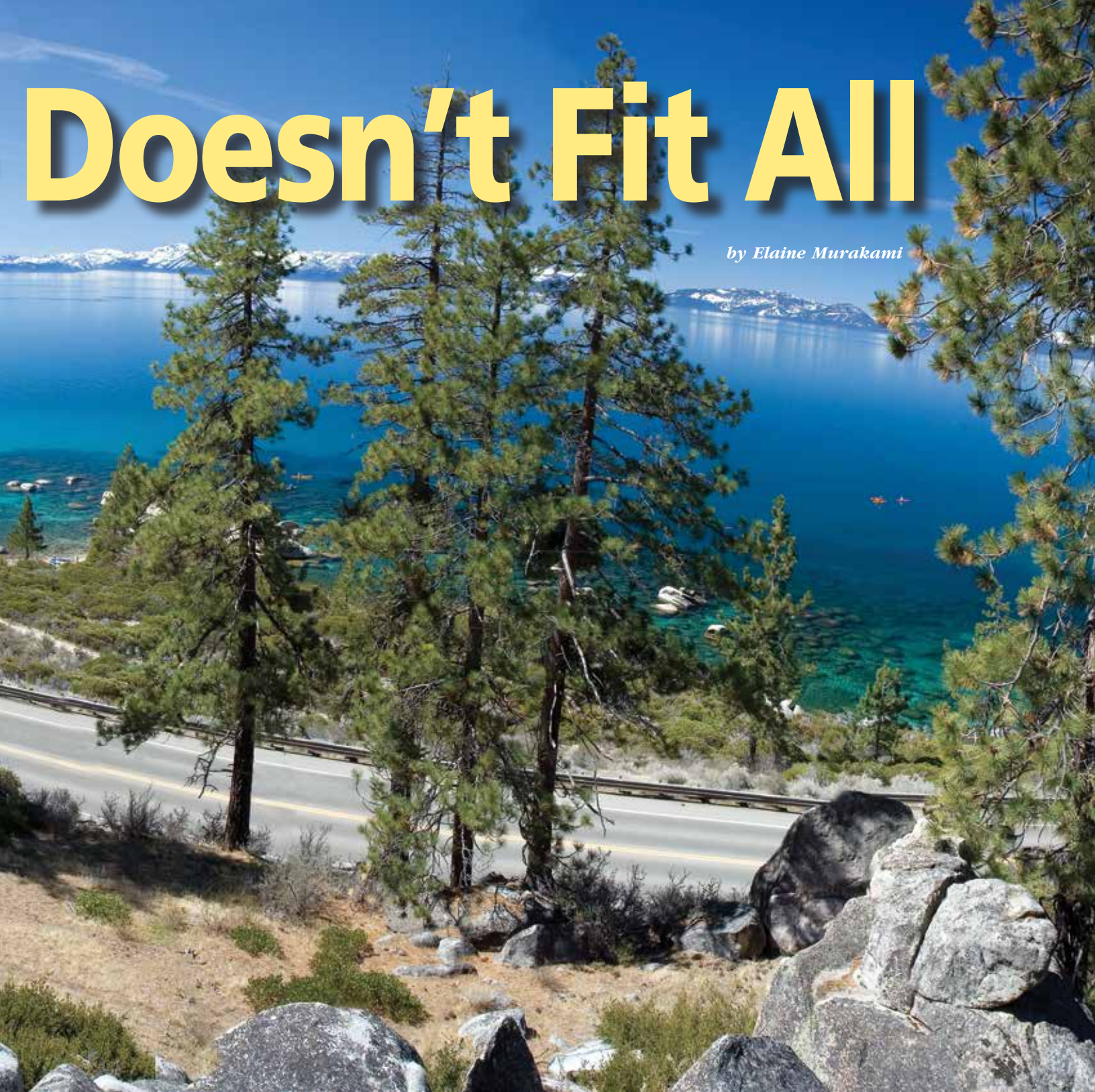
One Size



Smaller communities depend on a distinct set of solutions for overcoming obstacles to planning multimodal transportation facilities in their cities and towns.

(Above) The Tahoe MPO in California and Nevada is using increased public input to help balance the region's transportation needs while preserving the natural resources, including scenic Lake Tahoe, shown here. *Photo: Tahoe Transportation District.*

Regardless of the size of a community, residents need to be able to access jobs, schools, health care facilities, stores, entertainment, and more. Federal regulations for transportation have different requirements for urbanized areas (as defined by the U.S. Census Bureau) with populations of more than 200,000. The Transportation Research Board's (TRB) Committee on Transportation Planning in Small and Medium-Sized Communities (ADA 30)



Doesn't Fit All

by Elaine Murakami

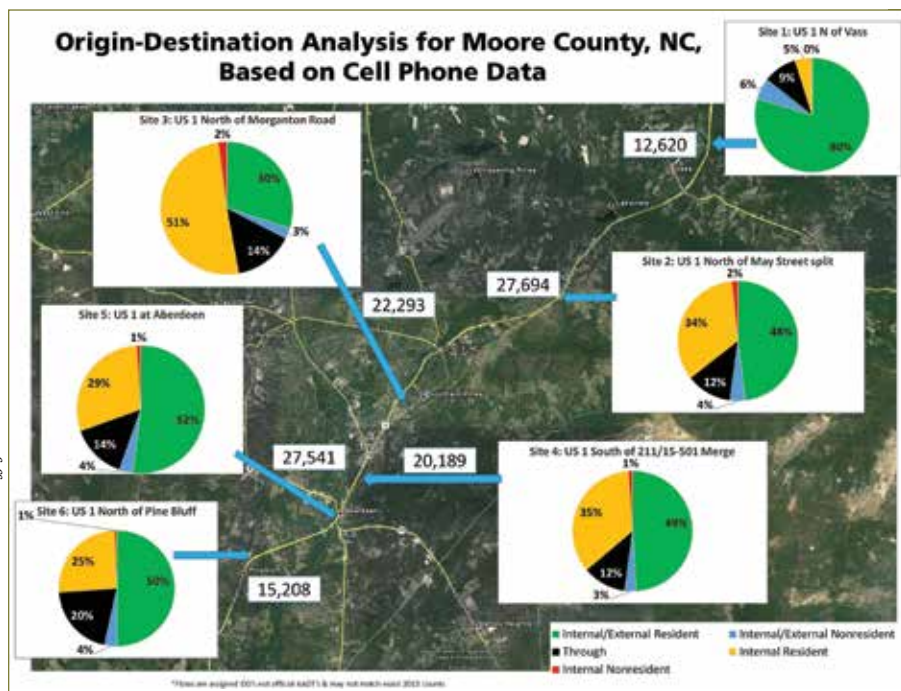
generally works with communities that have populations below that threshold. These small and medium-sized communities must address many of the same issues as larger metropolitan areas, but with fewer staffing resources and smaller budgets. Finding cost-effective solutions to developing accurate travel models, evaluating

projects for long-range planning, and improving public participation are all critical for success.

To help transportation professionals charged with planning and programming for multimodal transportation facilities, the TRB Committee on Transportation Planning in Small and Medium-Sized Communities holds a biennial Tools

of the Trade conference. The most recent took place in Burlington, VT, in July 2014, and focused on economical, ready-to-use, and practical tools and techniques for smaller communities. Attendees also discussed future research and implementation needs.

Here is a look at a few of the innovations featured at the conference.



NCDOT used aggregate cell phone data to evaluate travel patterns along U.S. 1 in Moore County. The analysis identified how the corridor serves its users locally, regionally, and state-wide. By understanding how these groups use the corridor, NCDOT can approach transportation planning more strategically.

it does not show individual cell phone records and therefore it is not subject to privacy issues. North Carolina plugged the data into a travel demand model developed by a contractor to assess the traffic patterns along the U.S. 1 corridor. The traffic patterns showed NCDOT how local, regional, and statewide traffic use the corridor, thus helping them plan for improvements with a more strategic and cost-effective approach.

Both State and local planners view the project as a success because it helped NCDOT determine where the traffic was coming from and traveling to, and plan for expected growth in volume on the affected roads.

Frances D. Bisby, transportation engineer in the NCDOT Transportation Planning Branch says, "Confirming the existing travel patterns of the county's roadway users, and specifically, the breakdown of internal versus external traffic, [was] vital for the decision-making process and in planning the future of the U.S. 1 corridor."

Bisby adds, "Finding solutions to capacity [issues] within urban settings is a problem facing more and more communities as our State and local planning agencies try to balance safety, mobility, and constrained resources within the context of local communities. Having an analysis tool [and data]...helps make sure that the plan under development reflects local travel patterns. The ultimate goal is a transportation plan that will accommodate the projected growth of the county's traffic and provide the best operational solution for the county's future transportation needs."

New datasets and tools for improved modeling of travel demand support better planning decisions in small and medium-sized communities at reduced costs. TRB is currently working on a project (08-95)

Using Aggregate Cell Phone Data

Developing travel models at the local level can be challenging due to the high costs of conducting household surveys, which typically run from \$150 and up per completed survey. However, travel surveys have been a staple of model development for decades. Some major metropolitan areas plan for a sample size of at least 1,000 (some significantly more) households every 10 years, but that is out of reach for smaller metropolitan planning organizations (MPOs).

In lieu of locally collected data, many communities borrow model parameters from other locations with similar populations and adjust as needed based on comparisons of estimated traffic flows to observed traffic counts. Examples of the parameters are trip rates (the number of household trips daily) and distribution curves for trip lengths. Typically, household trip rates transfer fairly well, but the distribution of trips to reflect local land use and development patterns in each community are less transferrable.

A recent project in North Carolina used data from cell phones to analyze corridor traffic, in particular to determine the proportion of travel by local residents compared to visitors. For the U.S. 1 corridor in Moore County, the North Carolina Department of Transportation (NCDOT) needed a model to

evaluate travel patterns and traffic demand. Moore County, with a population of more than 91,000, is located in central North Carolina. The comprehensive transportation system serving the county includes major corridors such as U.S. 1, U.S. 15, and U.S. 501. With population growth nearing double digits over the last decade, the corresponding increase in traffic volume is straining the existing infrastructure.

Working with the Triangle Area Rural Planning Organization and the county's 11 planning jurisdictions, NCDOT needed to determine the source of the traffic volume contributing to the mounting congestion in the corridor. Agency officials also needed to know how much of the traffic was local and how much came from outside the county, and how the county's anticipated growth would affect the corridor by 2040.

The solution? NCDOT obtained location data from cell phones to determine major origin-destination patterns and to understand the traffic flows along U.S. 1. The data helped to clarify the potential need for corridor improvements.

NCDOT purchased the aggregate cell phone data at the traffic analysis zone (a unit of geography defined for transportation planning) level from a wireless information and data provider for a fraction of the cost of a traditional survey. Because the data is completely aggregate,

under the National Cooperative Highway Research Program to better understand the extent to which location data from cell phones accurately depict travel patterns and to provide guidelines on the use of these data. Information on the project is available at <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3637>.

Applying Technology to Long-Range Planning

Long-range plans typically include two types of projects: those that are visionary (no funding available) and projects that are fiscally constrained. Only fiscally constrained long-range projects can be selected for implementation because funding must be available or reasonably expected to be available for projects to move forward. Therefore, MPOs need a way to evaluate each project based on targeted outcomes (for example, contribution toward performance goals) for consideration and inclusion in long-range plans, as well as shorter term transportation improvement programs (TIPs). Traditionally, MPOs each developed their own systems for planning, which could be quite labor-intensive for smaller MPOs with fewer staff members. Now, WebTELUS (Trans-

portation Economic Land Use System) can help agencies with performance-based planning and selecting projects strategically.

WebTELUS, available at www.telus-national.org, is a software tool designed to make long-range transportation planning more accessible to the public by using data visualization in a Web-based geographic information system (GIS) environment. It also provides planners and decisionmakers with options for tracking project information, schedules, and funding commitments and for relating project selection to regional performance goals.

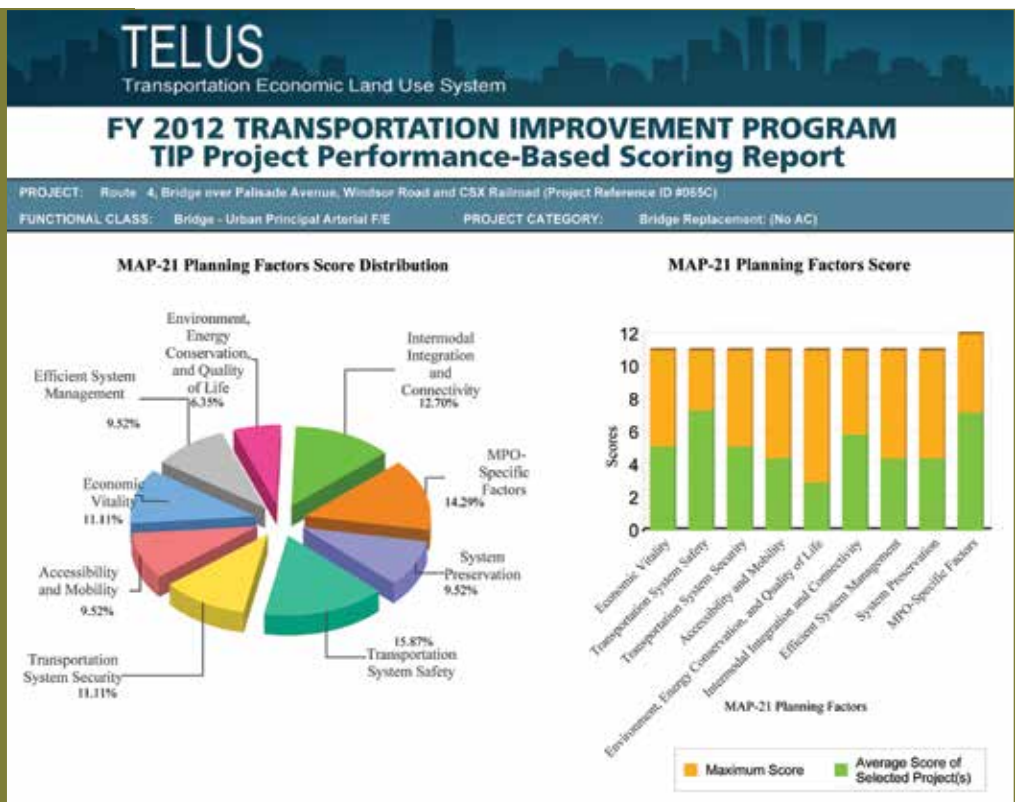
Many large MPOs already use GIS-based reporting systems for developing TIPs, which list projects to be funded with Federal Highway Administration (FHWA) and Federal Transit Administration dollars over the next 4-year period. Some of them (for example, the New York Metropolitan Planning Council) use the TELUS platform. However, WebTELUS may be useful and beneficial to small and medium-sized MPOs because it is available to public agencies free of charge. In addition, the existing framework can be easily customized, making it a cost-effective solution. WebTELUS comes with standard

reports, but agencies can develop customized reports using the project information in the database.

In WebTELUS, agencies can link each project to specific factors and criteria used in planning or project selection. Users can define the criteria or base them on default factors provided in the software. Each agency also can customize the rating system to meet its needs and match its business processes. This system makes it easy to tie projects to State or regional transportation performance goals and to analyze the contribution of the selected projects to each goal. The GIS component can include a variety of visualization tools, including links to an agency's VideoLog application or Google Street View™ mapping service to show the location of each project.

FHWA has been working with the New Jersey Institute of Technology to develop WebTELUS. Congress initiated the project with an earmark under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The objective is to develop management information systems to assist State departments of transportation (DOTs) and MPOs with the planning and programming requirements mandated under this legislation.

This sample report, generated using the WebTELUS software, scores a proposed bridge project according to its anticipated performance and various planning factors from the Moving Ahead for Progress in the 21st Century Act (MAP-21). The graph provides a breakdown of the relative impacts the project would have on various planning objectives based on the scoring. Planners can use this to help select projects to meet the planning objectives by comparing proposed projects according to planning factors. (Note: The scores for this sample project are for illustration purposes only. They were not assigned by the MPO or DOT and may not accurately reflect the actual scores or merits of the projects.)



Source: New Jersey Institute of Technology TELUS Project

WebTELUS provides a mechanism for collecting public comments on proposed transportation improvement projects, as shown here.

“With the passing of ISTE, we recognized a need to develop a management information system that would be very easy to use, could store and manipulate large amounts of data, and could present this data to decisionmakers and citizens in a simple, coherent, and timely manner,” says Lazar Spasovic, TELUS project director at the New Jersey Institute of Technology. “The decision was made to develop this tool through a collaborative research program driven by users’ needs, adopting the FHWA Technology Innovation Life Cycle approach.”

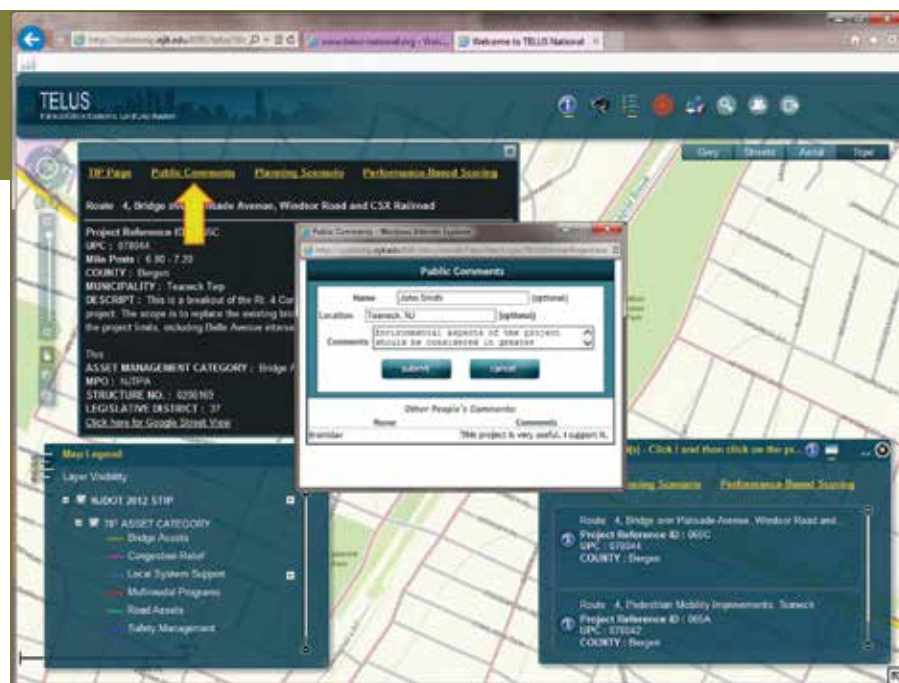
Recognizing the prospective value of TELUS and its potential to meet users’ needs, FHWA designated the tool as a priority, market-ready technology in 2003 to help expedite its adoption. The designation meant FHWA helped to get the technology marketed effectively, communicated, and understood by potential users.

WebTELUS became available in 2004. The off-the-shelf version of WebTELUS also includes a tool for the public to comment on individual TIP projects.

An agency can customize the software either using internal resources or with assistance under contract from the New Jersey Institute of Technology. In the latter situation, the agency provides a TIP spreadsheet or database and detailed maps for each project, which the staff at the New Jersey Institute of Technology then enters into the WebTELUS system. The institute staff also can provide cloud-based hosting for the system, including system maintenance, which could be a cost-effective option for agencies that do not have full-time staff dedicated to information technology.

How DOTs and MPOs Are Using TELUS

The Alabama Department of Transportation, Miami Valley Regional Planning Commission, and Houston-Galveston Area Council are some of the early adopters of WebTELUS.



Source: New Jersey Institute of Technology TELUS Project.

“The Miami Valley Regional Planning Commission has been using WebTELUS for nearly a decade with great success,” says Mike Lucas, information technology and Web manager for the planning commission. “Our staff uses it daily to maintain and update project data, and providing Web access for visitors has simplified and often reduced the number of meetings needed with project sponsors.”

Lucas says that the ability to modify the code of the application has enabled the planning commission to customize some portions of it, including accessing the data for specialized queries. “And an open line of communication with the TELUS/New Jersey Institute of Technology staff has always resulted in quick problem-solving when we’ve needed it,” he adds.

Another application of TELUS, which evolved from the Web-based system, is TELUS eSTIP, an application that streamlines the development, review, and approval of TIPs and STIPs (statewide transportation improvement programs), as well as the processing of amendments and modifications, and facilitates cooperation between agencies at all levels. The application also enables stakeholders, including the public, to quickly review submitted project actions and track the progress of approvals as they move through the process. This application, however, does not allow for public comments.

Both the New Jersey Department of Transportation (NJDOT) and the New York Metropolitan Transportation Council have implemented the system to manage their programming processes. James F. Vari, program manager in NJDOT’s Division of Capital Investment Planning and Development, is pleased with the outcomes of implementing TELUS eSTIP. “A fully integrated [eSTIP] allows [us] to manage the STIP process, from planning and programming to the obligation of funds,” he says. “At the same time, eSTIP enables the MPOs, transit agencies, and independent authorities to manage their projects and programs.”

The software also helped NJDOT eliminate a lot of unnecessary paper-pushing along the way and improved the overall efficiency of the approval process. “With eSTIP,” Vari says, “we reduced the amount of time for both FHWA and [the Federal Transit Administration] to review and approve STIP modifications and amendments.”

Improving Public Participation

Public participation is a Federal requirement of regional transportation planning. It enables transportation agencies to make more informed decisions through collaborative efforts and builds mutual understanding and trust between

the agencies and the public they serve. Outreach to a broad range of stakeholders, including residents, business owners, advocacy groups, and commercial property owners and operators, yields the most comprehensive input. But what if many of your constituents are seasonal residents or tourists? How do you engage them when they cannot participate at meetings in person?

The Tahoe Metropolitan Planning Organization, a joint effort between California and Nevada, is using virtual meetings to increase public participation and advance its regional transportation goals while preserving natural resources that are critical to the local economy.

Lake Tahoe is a stunning alpine lake set high in the Sierra Nevada, 2 hours northeast of Sacramento, CA, and about 3 hours from San Francisco, CA. The Tahoe MPO has goals to increase the safety, security, and efficiency of its multimodal transportation system, which includes highways, bus transit, ferries, and shared-use trails. The MPO emphasizes walkability and preserving Lake Tahoe's famed water quality and other environmental resources. Both of these planning directions support the local economy, which relies heavily on tourism, and the natural resources and distinctive communities that attract tourists.

Controlling stormwater runoff and reducing greenhouse gas emissions by encouraging use of non-automotive modes of transportation are part of the goal to maintain the air and water quality of the region and preserve sensitive lands.

"Our goal was to get people involved in Mobility 2035, our regional transportation plan," says Karen Fink, senior transportation planner with the Tahoe MPO. "We have a lot of seasonal residents and visitors . . . here at Lake Tahoe, so we needed a way to reach those constituents, even if they were not able to attend an in-person meeting. By using a combination of hands-on methods for people attending an onsite meeting, and easy-to-use

methods for virtual, realtime participation, we anticipated that we could increase participation."

For the first time, the MPO implemented a Web-based application called Crowdbrite to engage stakeholders who could not attend meetings in person. Crowdbrite is an online platform for hosting brainstorming sessions, meetings, workshops, and charrettes. When users log into a session, they see a digital "white board" with virtual sticky notes containing comments, and photos and maps of the project area. The maps are clickable, which enables users to select a specific project, and then submit comments on that project as well as read comments from other users.

The application proved to be an effective means for increasing public participation in the planning process. "We received a great deal of positive feedback from using the Crowdbrite approach," Fink says. "People were excited about the computer interface."

Fink adds that online participation was comparable and complementary to the onsite meetings. "Onsite, people could use traditional sticky notes or computer tablets to identify project preferences or problem situations. Online participants could submit electronic sticky notes. Crowdbrite staff worked on adding the paper comments into the electronic system so that all comments were accumulated in one place. Making all the comments—submitted both onsite and electronically—easy to see made interaction easy

and allowed people to discuss their ideas on specific projects with each other, both in person and online." In addition, Fink says the improved interaction facilitated the generation of new ideas, such as identifying locations for safety improvements for bicyclists and pedestrians.

Within 20 minutes of the conclusion of the event, Crowdbrite generated a summary of all the comments submitted. The quick turnaround was important in gaining public trust, because people saw that their comments were included. After the summary was posted and made available publicly, an online open house enabled people to submit comments for an additional month.

During a recent workshop to kick off a corridor improvement project in a rural area, event organizers asked 70 stakeholders to share the Crowdbrite project Web site with their peers and social networks. The company provided computer kiosks onsite or the stakeholders used their tablets or smartphones to do it immediately. Within an hour, the effort had identified nearly 9,000 people as potential participants. Compared to the original 70, that number is significant. Plus, being invited by peers rather than by public notice resulted in meaningful input and an increase in participation—at no additional cost.

"The Crowdbrite approach is a process focused on impact and meaningful outcomes," says Crowdbrite owner Darin Dinsmore. "We have been able to actually reduce the number of expensive

Jeff Cowen, former public information officer with Tahoe MPO, talks with a stakeholder during a public participation meeting.



Tahoe MPO

The Tahoe MPO is using Crowdbrite, an online application that supports virtual meetings, to gather public input. This summary report combines a map and photos with digital sticky notes containing comments received on the Lake Tahoe Regional Transportation Plan via in-person meetings and through virtual participation.

workshops while increasing access and participation and focusing more funds on project delivery and early catalyst projects.”

Crowdbrite is just one of many choices available for using interactive, Web-based systems, social media, and telecommunication to increase public involvement in the planning process. Several companies recently participated in a technology fair hosted by the International Association for Public Participation, including Intellitics, MetroQuest, PlaceSpeak, Telephone Town Hall Meeting, and Urban Interactive Studio.

Using Employment Data By Industry to Generate Regional Models of Truck Trips

Freight traffic is significant in some small and medium-sized communities, especially those near large distribution centers. Yet due to the highly aggregated nature of data in the Freight Analysis Framework, the proprietary nature of other sources of freight data, and the cost associated with collecting site-specific freight data, small and medium-sized communities often exclude truck trips in their travel demand models. To overcome these limitations, they assume truck trips as a portion of the non-home-based trips. However, inclusion of trucks in travel demand models does not provide the community the ability to plan the roadway infrastructure to account for actual truck demand.

The Freight Analysis Framework version 3 database, developed and maintained by FHWA, provides a snapshot of freight volumes for metropolitan areas across the Nation using freight analysis zones. However, some smaller communities, despite having reasonable freight activity, might not be included as a freight analysis zone in the



Source: Tahoe MPO and Crowdbrite.

database if they do not have direct access to the amount of freight transport in their communities.

To assist transportation agencies without local freight data at their disposal, the University of Alabama in Huntsville conducted a study to build regional models of truck trip generation. The study built models of trip generation using employment data by industry from 74 metropolitan regions (out of 381 in the United States) and 123 freight analysis zones.

Michael Anderson, professor of civil engineering at the University of Alabama Huntsville says the goal was to provide models that can be used anywhere in the country. “We used employment data by industry as the explanatory variable in the models,” he says. “We aggregated industry employment data from the North American Industry Classification System to two-digit level and developed a truck production and attraction model for each of 42 commodities at the two-digit aggregate level.” The two-digit level allows for classification of the data by industry.

Transportation planners can incorporate the trip generation models in a commodity-specific modeling approach. That is, entering the industry employment data for the community into the university’s model can produce an estimate of the total volume of freight expected to be imported into and exported from the community. These values represent the external-internal and internal-external movement of trucks.

University researchers tested the models developed against statistical parameters to ensure accuracy. They also examined the adequacy of the models using standard statistical tests. All of the models passed at a statistically significant level.

Although no model is perfect, Anderson says, “We are spending the public’s money without knowing all the data, so we have to try our best to use the existing data most effectively.”

For more information or to access the models, contact Mike Anderson at 256-824-5028 or andersmd@uah.edu.

Conclusion

Transportation planning in small and medium-sized communities requires creativity and willingness to think outside the box to accomplish goals while saving money. But when communities embrace new and emerging tools, they can increase public participation, improve travel demand models, and enhance transparency and accuracy in the planning process.

“I continue to be impressed by the diversity of innovative solutions to these challenges presented and the camaraderie of the participants at our Tools of the Trade conferences,” says Jerry Everett, research director at the Center for Transportation Research at the University of Tennessee, Knoxville, and chair of the TRB Committee on Transportation Planning for Small and Medium-Sized Communities. “These are the characteristics that



www.Shutterstock.com, Adam Bies

piqued my interest in this group more than a decade ago and what I hope our committee will continue to foster to help small and medium-sized communities thrive.”

For more information, visit www.trbtoolsofthetrade.org or contact Elaine Murakami at 206-220-4460 or elaine.murakami@dot.gov.

Here, a commercial truck carries freight across the New River Gorge Bridge in Fayetteville, WV.

Elaine Murakami is a community planner with FHWA’s Office of Planning in Washington, DC. She has worked at FHWA for more than 20 years. Prior to joining FHWA, Murakami worked at the Puget Sound Regional Council in Seattle, WA. Her work is focused on personal travel surveys, including using the American Community Survey for the Census Transportation Planning Products. Murakami has been influential in promoting innovations in conducting regional household travel surveys, such as using GPS and smartphones.

Joe Zietsman, head of the Environment & Air Quality Division of the Texas A&M Transportation Institute, is shown here making a presentation on performance measures for sustainability at the 2014 Tools of the Trade conference in Burlington, VT.

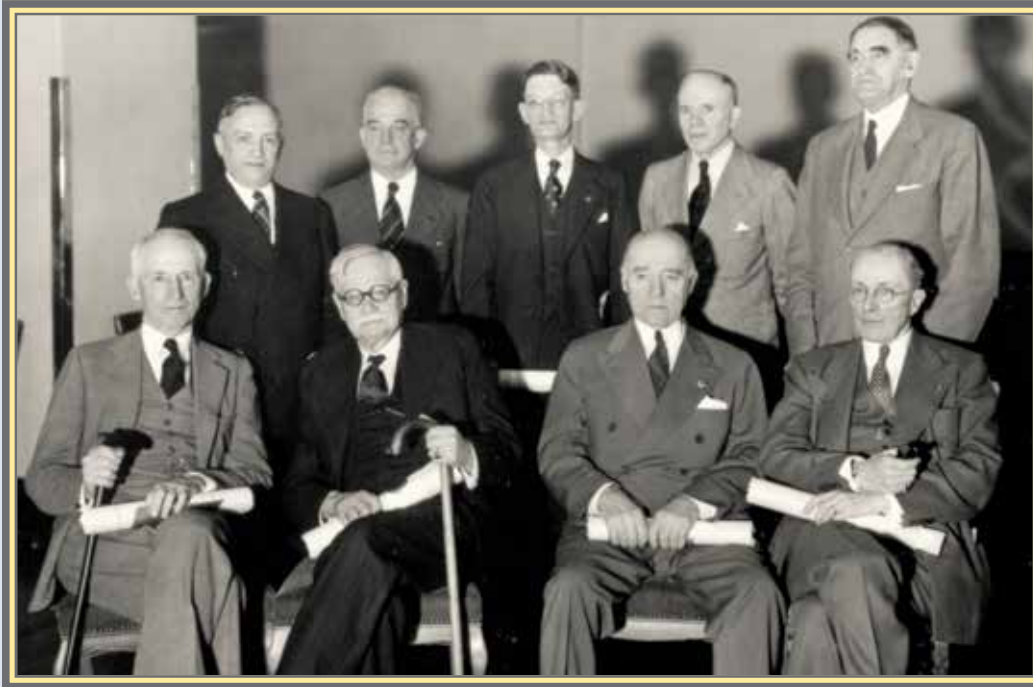


100th Anniversary



In honor of AASHTO's 100th anniversary, FHWA examines the historic State-Federal collaboration during the interstate era.

This two-part series concludes here.



In October 1939, AASHTO celebrated its 25th anniversary with a presentation of certificates to 15 surviving founding members. The nine in attendance for this photo were (seating unknown): Robert Platt Boyd, George P. Coleman, Charles M. Kerr, Charles P. Light, J. E. Pennybacker, Joseph Hyde Pratt, Frank D. Rogers, Paul D. Sargent, and Henry G. Shirley.

An Evolving Partnership

by Richard F. Weingroff

State highway officials formed the American Association of State Highway Officials (AASHTO) in December 1914. To survive 100 years, any organization must evolve in the context of social, economic, technological, and political changes. Before the interstate era, AASHTO evolved through the rough start of the Federal-Aid Highway Program in 1916, World War I, the Roaring '20s, the Depression and New Deal of the

1930s, World War II, and the postwar economic recovery and Baby Boom.

To read the first article in this two-part celebration of AASHTO's 100th anniversary, see "Celebrating a Century of Cooperation" in the September/October 2014 issue of PUBLIC ROADS. To continue the story, this second article details the evolution of AASHTO and its successor, the American Association of State Highway and Transportation Officials (AASHTO), as the premiere voice

of transportation officials around the country.

The Interstate System

Historians usually tell the story of the interstate system from a Federal perspective, with emphasis on the roles of Presidents Franklin D. Roosevelt and Dwight D. Eisenhower, Federal highway leaders, congressional action, and Federal reports such as *Toll Roads and Free Roads* (1939) and *Interregional Highways*

(1944). The Federal perspective is valid, but only if it includes AASHO/AASHTO as partners throughout the conception, launch, and construction of the Dwight D. Eisenhower National System of Interstate and Defense Highways.

Construction of the interstate system began in earnest after President Eisenhower signed the Federal-Aid Highway Act of 1956, but the history of the system began in the 1930s.

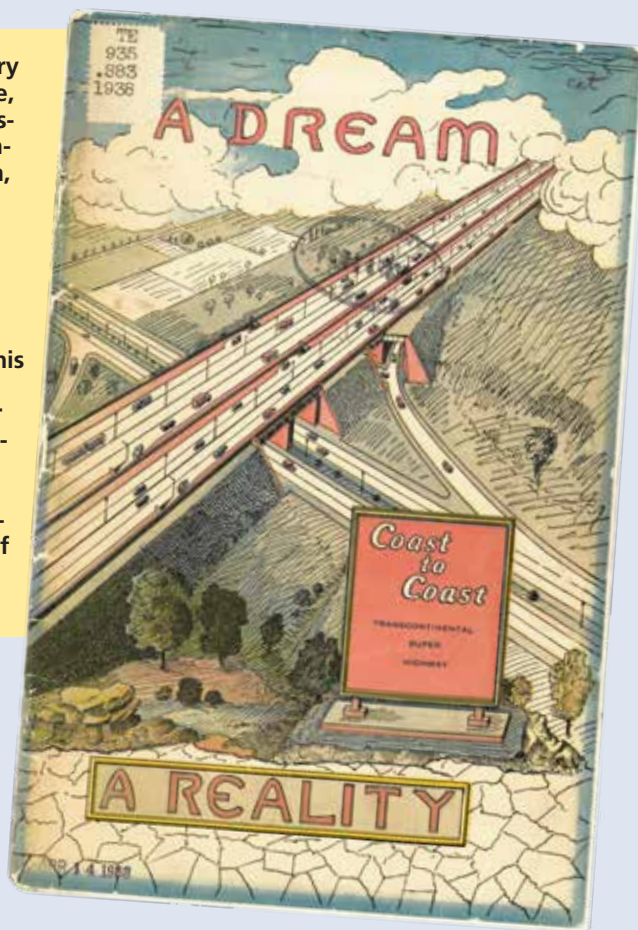
State Highway Planning Surveys

During the 1930s, proposals for transcontinental superhighways were common. The businessmen and visionaries behind the proposals usually saw them as toll roads with adjacent excess right-of-way that could be sold or rented for commercial or residential purposes to pay for the highway construction.

President Roosevelt favored such schemes. In February 1938, he called Chief Thomas H. MacDonald of the Bureau of Public Roads (BPR) to the White House and asked him to study the feasibility of building a network of toll superhighways with excess right-of-way. The President had drawn the routes on the 1935 edition of the "United States System of Highways" map.

MacDonald sent a report to the President in April, explaining that the superhighways on most of the network would not carry enough traffic for toll revenue to repay the construction bonds. The report concluded that superhighways were needed mainly in congested met-

During the 1930s, visionary proposals to build a single, straight-as-an-arrow transcontinental toll superhighway, or networks of them, were common, offering transportation and jobs at no cost to the Federal Government. T. E. Steiner of Wooster, OH, received extensive publicity and congressional interest in his proposal for a Transcontinental Steam-Lined Super Highway. The U.S. Department of Transportation Library has retained this 1938 brochure on the proposal for "The Highway of Tomorrow Made Possible by the Ideal of Today."



ropolitan areas and as connectors linking neighboring large cities. In addition, because of current State and Federal laws, the acquisition of right-of-way for the superhighways, let alone excess right-of-way, would be a major challenge that could best be met by establishing a Federal authority to acquire land not only for the superhighways but for all Federal land needs.

The report, however, was not made public. Instead, the Federal-Aid Highway Act of 1938 called on BPR to report to Congress on a similar concept.

By the time of the 1938 Act, MacDonald and his top aide, Herbert S. Fairbank, had finished analyzing the data for the report to Congress. The data were a result of the Hayden-Cartwright Act of 1934, which had authorized the State highway agencies to

use 1.5 percent of their Federal-aid apportionment "for surveys, plans, and engineering investigations of projects for future construction. . . ."

The States and BPR had sought this provision for a State-by-State national survey on road conditions. Included would be width, type, design, adjacent uses, and safety issues; traffic data, such as classification of vehicles, origin and destination data, and the cargo and weight of commercial vehicles; and financial and road use data.

In September 1935, Pennsylvania initiated the first survey for State highway planning. In the end, 46 States participated in the national survey, employing an estimated 15,000 men at the height of the field work, mostly from the relief roles during the peak of the Depression.

Toll Roads and Free Roads

Based on analysis of the data from the State surveys, BPR wrote *Toll Roads and Free Roads*, which President Roosevelt transmitted to Congress on April 27, 1938. The report, he wrote in the transmittal letter, "emphasizes the need [for] a special system of direct



President Roosevelt asked Chief Thomas H. MacDonald, shown here, of the Bureau of Public Roads, to study the feasibility of building a network of toll superhighways.

In this 1958 photograph, Executive Secretary Alfred E. "Alf" Johnson of AASHO (right) and Federal Highway Administrator Bertram D. Tallamy examine a map of the interstate system.



interregional highways, with all necessary connections through and around cities, designed to meet the requirements of the national defense and the needs of a growing peacetime traffic of longer range."

In its first part, the report explained that the surveys revealed that transcontinental and even long-distance traffic was light. Traffic was mainly local or regional. As a result, most parts of the country could not support the toll transcontinental superhighways suggested by the 1938 Act.

That conclusion should have ended the report that Congress had requested, but to provide a positive conclusion, BPR added a second part: *A Master Plan for Free Highway Development*. It advocated "a special, tentatively defined system of direct interregional highways, with all necessary connections through and around cities." Based on the statewide highway planning surveys and defense needs, the master plan described a proposed interregional highway system of about 26,700 miles (42,970 kilometers).

Interregional Highways

In 1941, President Roosevelt appointed a National Interregional Highway Committee "to investigate the need for a limited system of national highways to improve the facilities now available for interregional transportation." MacDonald, who was now commissioner of the Public Roads Administration (formerly BPR), was chairman, and Fairbank was secretary. Other active members included the following:

- G. Donald Kennedy, vice chairman, was Michigan's State highway commissioner and soon-to-be AASHO president (1941-1942). At the time, Kennedy was promoting defense access plans that would result in Detroit's first modern expressways.
- Charles H. Purcell was the State highway engineer in California (AASHO president, 1937-1938),

chief engineer of the San Francisco-Oakland Bay Bridge, and planner of the State's freeway system.

- Harland Bartholomew, famed city planner from St. Louis, MO, was an advocate of urban expressways who would lay out freeway networks in several cities, including Washington, DC.

Three other members were from outside the highway community and played limited roles in the committee's activities.

The committee essentially completed its work in October 1941 but put its report aside after the bombing of Pearl Harbor on December 7, 1941, as the country's focus shifted to highways for defense.

During the war, the Public Roads Administration worked with AASHO, its member highway agencies, and the Department of War to establish and improve a strategic network of highways and access roads to military reservations and defense industrial plants. In 1942, AASHO published the *Manual on Uniform Traffic Control Devices for Streets and Highways—War Emergency Edition* (MUTCD). It included standards for traffic control when cities in wartime blackout prohibited all lights, including vehicle headlights, to thwart potential bombing attacks. (For more on the MUTCD, see the first part of this series in the September/October 2014 issue of PUBLIC ROADS.)

On July 13, 1943, President Roosevelt approved legislation that authorized Federal-aid funds for defense needs and directed the Public Roads Administration to work with

State highway officials to develop highway plans for the postwar era. The plans were to address the provision of jobs for homecoming soldiers after the war to prevent a return of Depression-era unemployment levels. The legislation also asked the commissioner of the Public Roads Administration to report to Congress within 6 months on "the need for a system of express highways." In essence, Congress wanted the interregional committee's report.

President Roosevelt submitted *Interregional Highways* to Congress on January 12, 1944. He said the report recommended "a national system of rural and urban highways . . . interconnecting the principal geographic regions of the country." This "transcontinental network of modern roads" would help "meet the Nation's highway transportation needs" and, during the country's postwar readjustment period, would absorb "a substantial share of the manpower and industrial capacity then available."

The Federal-Aid Highway Act of 1944, which President Roosevelt approved on December 20, authorized Federal-aid highway funds for the postwar period. In addition, section 7 called for designation of a National System of Interstate Highways not exceeding 40,000 miles (64,374 kilometers) "to connect by routes, as direct as practicable, the principal metropolitan areas, cities, and industrial centers, to serve the national defense, and to connect at suitable border points with routes of continental importance in the Dominion of Canada and the

Republic of Mexico.” The routes were to be “selected by joint action of the State highway departments.”

The 1944 Act did not authorize special funds for the new system, which was eligible for improvement with Federal-aid highway funds. The Federal-State matching ratio would be the same as for other systems: 50/50. Nevertheless, in section 7, Congress set the interstate highway program in motion.

First Steps Launch the Interstate Program

In February 1945, the Public Roads Administration asked each State highway agency to recommend routes for inclusion in the interstate system. Designation procedures had been formulated in cooperation with AASHO’s Subcommittee on Legislation and Administrative Policy.

Simultaneously, the Public Roads Administration worked with AASHO’s Committee on Planning and Design Policies to develop standards for the location and design of interstate highways. AASHO adopted the design standards on August 1, 1945.

The standards included the following:

- A 20-year design period
- Full control of access where State law permitted it or, where not permitted, frontage roads for property service
- Grade separation of crossroads and railroad crossings except where traffic was so low that construction of a separation structure was not economically justified
- Two-lane sections on lightly traveled rural segments

On August 2, 1947, the Public Roads Administration and its parent Federal Works Agency announced designation of 37,681 miles (60,641 kilometers) of the Nation’s prin-

cipal highways, including 2,882 miles (4,638 kilometers) carrying the main lines through cities. The routes were assigned neither names nor numbers; they were simply black lines on a map. The Public Roads Administration reserved the remaining miles for urban circumferential and distributing routes, with the intention of working with State highway, county, and city officials to plan urban segments.

Alfred E. “Alf” Johnson

When Hal H. Hale, an engineer from Tennessee, resigned at the end of 1954 as executive secretary of AASHO, the association established a committee, consisting of John A. Volpe of Massachusetts, Bertram D. Tallamy of New York, and Rex M. Whitton of Missouri (all future Federal Highway Administrators), to select the next executive secretary. They chose Alfred E. “Alf” Johnson, AASHO’s president at the time, who was then endorsed unanimously by AASHO’s membership.

Johnson would help launch and sustain the interstate era through its most active period before his retirement at the end of 1972. (AASHO changed Johnson’s title to executive director in 1966.) An Arkansas native, Johnson had worked his way up through the State Highway Department, starting as rodman and instrument man in 1927 and becoming chief engineer in 1947.

During that period, he met Francis C. “Frank” Turner, who moved to Little Rock in 1933 as a BPR area engineer. Their friendship would prove instrumental at the start of

the interstate era, especially after Turner became Federal Highway Administrator (1969–1972).

In 1954, Johnson was AASHO’s president when President Eisenhower unveiled his Grand Plan for the Nation’s highways at the Governors’ Conference in July. (Due to a death in the family, Eisenhower could not attend; Vice President Richard M. Nixon delivered the speech.) The Grand Plan involved creating “a properly articulated system” to meet transcontinental, intercity, farm-to-market, and urban highway needs. Each level of government would improve its own highways. The President also supported the existing Federal-State partnership that ensured the most efficient level of government would be the manager of its own area.

In addition, the Grand Plan included “a program initiated by the Federal Government, with State cooperation, for the planning and construction of a modern State highway system . . . to construct new, or modernize existing highways.” That was as close as President Eisenhower came to mentioning the interstate system in announcing the Grand Plan. These highways would be financed on a “self-liquidating” basis through tolls or an increase in the existing Federal gas tax.

In November, Johnson delivered his address as outgoing president during AASHO’s annual meeting. Based on the President’s proposal, Johnson said that an expanded highway program, focused on a “nation-wide ultramodern interstate system,” was a “certainty.” He believed the

President Dwight D. Eisenhower’s leaders for the interstate highway program were Secretary of Commerce Sinclair Weeks (left), whose Department included BPR; the first Senate-confirmed Federal Highway Administrator, Bertram D. Tallamy of New York (center); and the first appointed Federal Highway Administrator, John A. Volpe of Massachusetts.





Alfred E. "Alf" Johnson of Arkansas (left) served as president of AASHO in 1954 before becoming its executive secretary in 1955 (the title was changed to executive director in 1966). In 1959, Rex M. Whitton, chief engineer, Missouri State Highway Department, and a future Federal Highway Administrator (1961–1966), presented AASHO's Thomas H. MacDonald Award to Johnson for outstanding achievement.

program should be carried out through the traditional Federal-State partnership that "has proved its worth and efficiency over the years."

Johnson left his AASHO presidency with these words: "Without doubt the opportunity we have been awaiting is upon us, and as soon as it is, let us be ready, let us have vision, let us be equal to the task, let us do the job with distinction and honor and above all let us design and build [adequately] for the future. Think big, have confidence, and start your planning for this program from this very moment."

Launching the Interstate Program

Johnson was already working on the new program. Commissioner of Public Roads Francis V. du Pont of BPR, as the agency was again named, and the President's top aide, former New Hampshire Governor Sherman Adams, had appointed Johnson, still AASHO's president, to an advisory committee that included several State highway officials. They prepared a proposal for du Pont based on the concepts in *Interregional Highways*.

Adams also asked Johnson to work with the Governors. When Vice President Nixon delivered the President's Grand Plan speech, the Governors were about to approve their annual resolution calling for the Federal Government to devolve most of the Federal-aid highway program to the States. The White House called on several friendly Governors, as well as Johnson, to persuade the Governors to drop their resolution

and cooperate with the President. Reluctantly, the Governors did so.

President Eisenhower asked retired General Lucius D. Clay to head a committee to develop a program to realize the Grand Plan. The Clay Committee did not include a highway builder, but Frank Turner provided expertise and access to BPR's data. Johnson, a special advisor to the Clay Committee, was disappointed when General Clay rejected the drafting committee's idea of financing the new program with revenue from highway user taxes.

In *A 10-Year National Highway Program*, the committee called for a \$27 billion interstate system program to be financed by a Federal corporation that would issue construction bonds, with the debt backed by the existing 2-cent Federal excise tax on gasoline. The 90-percent Federal share left the States to pay about the same dollar amount as needed to match the token amount of interstate funds under the Federal-Aid Highway Act of 1954 at a 60/40 matching share.

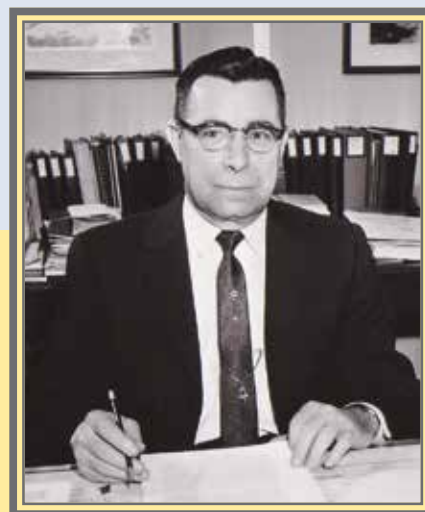
On February 22, 1955, President Eisenhower sent the plan to Congress, where it immediately ran into objections focused on financing.

Francis C. "Frank" Turner, shown in his office, retired as Federal Highway Administrator in 1972. His long friendship with Alfred E. "Alf" Johnson, who became AASHO's executive secretary, smoothed coordination between the two organizations during the interstate era.

Critics argued that the plan tied up the gas tax for 32 years and would pay \$12 billion, not to build roads, but to repay bondholders. All financing plans, including one based on increased highway user taxes, were defeated at the end of the session in July. The truckers, oil companies, and other highway interests wanted the interstate system but did not want to pay additional taxes to build it.

In *Mandate for Change, 1953–1956: The White House Years*, Eisenhower wrote that his aides suggested he call a special session on the issue. "Well," I said, somewhat ruefully, 'the special session might be necessary—but calling it could be at the cost of the sanity of one man named Eisenhower.'"

Following defeat of the bill, the White House, BPR, and highway interests, including Johnson, searched for an acceptable financing mechanism. AASHO met with Sherman Adams; Secretary of Commerce Sinclair Weeks; Senator Albert Gore, Sr. (D-TN), chairman of the Subcommittee on Roads; and Representative George H.



In front of a building located at the site of the Idaho road test, the engineering crew posed before preparing for a day's work constructing the site.



Fallon (D-MD), Gore's House counterpart who had prepared the failed House bill linking the interstate system to highway user tax revenue.

In September 1955, BPR released *General Location of National System of Interstate Highways*, known as the Yellow Book because of the color of its cover. The Yellow Book contained the August 1947 map of the interstate system plus maps showing the designated interstate mileage in major cities. It helped solidify support for the interstate system among urban Members of Congress.

By the time Congress returned in 1956, the interests had coalesced in support of a linkage between highway user tax revenue and the expanded program. Chairman Fallon released a new version of his 1955 bill while Representative Hale Boggs (D-LA) of the House Ways and Means Committee developed the Highway Revenue Act of 1956, which created a Highway Trust Fund in the general Treasury. Congress completed work on the combined bill quickly.

On June 29, President Eisenhower signed the Federal-Aid Highway Act of 1956 without fanfare or even a photograph, as he was recovering from surgery at the Walter Reed Army Medical Center at the time. Alf Johnson, on behalf of AASHO, was among those who received a pen used in the signing. The pen remains on display in AASHTO's offices, along with pens used to sign other legislation.

Federal Highway Administrator

Given the importance of the new program, the Eisenhower Administration decided that the head of BPR should be a presidential appointee and confirmed by the Senate. As Secretary of Commerce Sinclair Weeks explained, the prestige of a presidential appointment would help the new leader "in dealing with the State officials expected to take part in the administration of a highway program of the magnitude and character entrusted to this department."

Congress approved the legislation establishing the position of Federal Highway Administrator, and President Eisenhower signed it on August 3, 1956.

On October 12, the White House announced that the President had selected Bertram D. Tallamy of New York for the new post. He had served as New York's Superintendent of Public Works (appointed in 1948), the position he held when he became AASHO's president (1951–1952). However, he was best known as the driving force behind the New York State Thruway. Tallamy's selection was widely applauded, but he was not available immediately because of commitments in New York.

The President appointed John A. Volpe of Massachusetts as interim administrator, a temporary position that would not require Senate confirmation. Volpe, who had been Commissioner of Public Works in Massachusetts for 4 years, had planned to return to his Volpe Construction Company, but deferred his return at the President's request. On October 22, he took the oath of office at the White House. He served until February 5, 1957, when Secretary Weeks administered the oath of office to Tallamy.

Design Standards

Even before enactment of the 1956 Act, BPR had been working with AASHO's Special Committee on Administrative Design Policies to update the 1945 interstate design standards. *America's Highways 1776–1976* described the major items in the new minimum standards: "Control of access through-

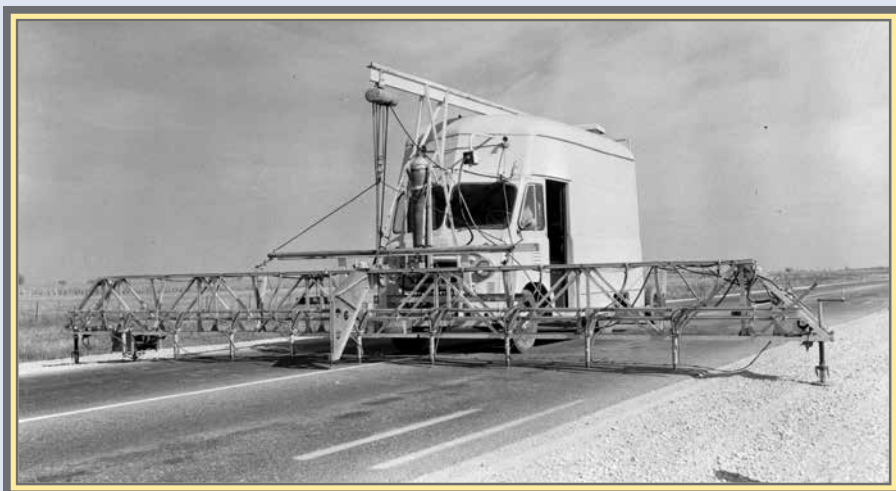
out the system; design adequacy for projected 1975 traffic—later changed (in the Federal-Aid Highway Amendments Act of 1963) to a 20-year minimum design period from the date of project approval; 12-foot [3.6-meter] travel lane width; 10-foot [3.0-meter] minimum shoulder width; elimination of railroad grade crossings; elimination of highway at-grade intersections; design speeds of 50, 60, and 70 miles (80, 97, and 113 kilometers) per hour respectively for mountainous, rolling, or flat terrain conditions; curvatures and gradients consistent with design speeds; separated traffic lanes with variable median widths on a right-of-way adequate in width to accommodate these standards; and minimum widths for highway bridges."

AASHO adopted the new geometric design standards on July 12, 1956, and BPR adopted them on July 17.

AASHO Road Test

Early in the century, highway officials had searched for ways to improve road surfaces. In 1918, BPR undertook a road test on the Agriculture Department's experimental farm in Arlington, VA, to measure the impact of varying loads on concrete, brick, and bituminous slabs, laid on a circular track. Several road tests followed with varying sponsors over the years.

After World War II, AASHO pursued new systematic experiments assessing the service life of highway pavements. In 1949, an AASHO special committee that included Alf Johnson and the Public Roads Administration's Fairbank, established procedures for initiating and overseeing road



This transverse profilometer was used at 2-week intervals to measure changes in the pavement surface at the AASHO road test site in Illinois.

tests. The road tests were to be jointly financed by multiple State highway agencies and were to provide data to develop longer lasting pavements for increased traffic.

The first of these road tests took place in 1950 and 1951 on a stretch of U.S. 301 in LaPlata, MD, to measure the impact of round-the-clock traffic on concrete pavements. The Highway Research Board administered this road test, which was financed by Maryland and 10 other eastern States, the District of Columbia, BPR, truck manufacturers, and the Highway Research Board.

In 1951, the Western Association of State Highway Officials, a division of AASHO, launched a road test to establish load limits for asphalt pavements. Eleven western States joined with BPR and the Highway Research Board for the test on two four-lane loops built in Malad, ID. The test, which ended in 1954, revealed information about the stresses on flexible pavements under varying truck loadings.

The Mississippi Valley Conference of State Highway Departments was considering a third test until AASHO concluded that an expanded test was needed, this time with varied cross sections including asphalt and concrete pavements, a wide range of axle loads, and load impacts on bridges. The test site in Ottawa, IL, was financed by a

joint fund of the 48 States, BPR, and others. It consisted of 7 miles (11.3 kilometers) of two-lane pavements in the form of six loops and a straight segment, half concrete, half asphalt. (The straight portion, built with Federal-aid funds, became part of I-80.) The 836 test sections employed a wide range of surface, base, and subbase thicknesses, and included 16 short-span bridges.

The Highway Research Board administered the expanded AASHO road test in Illinois, and the Department of Defense provided vehicles and drivers. Traffic began rolling on October 15, 1958, and ended November 30, 1960.

The test data established the relationships for structural designs based on expected loadings over the life of a pavement. Although the bridge findings were consistent with predictions, the AASHO road test provided the foundation for analytical evaluation of stresses and deflections from moving vehicles. It also set the stage for such similarly comprehensive

technical studies as the Long-Term Pavement Performance program begun in 1987 as part of the Strategic Highway Research Program.

The AASHO road test in Illinois was a landmark in highway and bridge design that has never been equaled.

Interstate Numbers And Signs

When BPR designated the rural interstates in 1947 and the urban segments in 1955, the routes appeared as black lines on maps. The bureau did not assign numbers to them. For numbering and marking the interstate system, the agency turned to AASHO.

In reply to a request from Alf Johnson, State highway officials submitted more than 100 designs for the interstate shield. The AASHO Route-Numbering Subcommittee selected the four best designs and posted the signs along a paved county road in Illinois when State highway officials were visiting the AASHO road test. The officials saw the markers by day and night and in sunshine and rain. The chosen design combined Missouri's and Texas's designs.

In August 1957, AASHO and BPR decided to adapt the U.S. numbering plan, which AASHO had approved in November 1926, for the interstate system, but in mirror image. Where the lowest odd-numbered U.S. route was on the east coast (U.S. 1), the lowest odd-numbered

At AASHO's request, State highway agencies each submitted a proposed shield for the new interstate system. Shown here are two of the proposals that were not adopted.



interstate route would be on the west coast (I-5). Similarly, the lowest even-numbered U.S. route was along the Canadian border (U.S. 2), but the lowest numbered transcontinental interstate route was to be in the South (I-10). The committee applied interstate numbers within the resulting grid.

On August 29, Johnson submitted the plans to Administrator Tallamy, along with a "Numerology Map," a purpose and policy statement for the numbering, and a photograph of the approved shield. In early September, Tallamy approved AASHO's proposals.

One remaining issue was the color of the guide signs along the interstate routes. Tallamy preferred blue, the color of the signs on the New York State Thruway. Other officials preferred green. To resolve the issue, BPR and AASHO staged a 2-week test on an unopened section of the Capital Beltway near Greenbelt, MD. Signs were erected in blue, green, and black, some reflectorized, directing motorists to "Metropolis" and "Utopia."

Hundreds of test motorists commented on the color, shape, and words on the signs. The results were decisive, with 58 percent picking the green background. Results in hand, Tallamy approved the white-on-green design in January 1958.

The following month, AASHO released the first *Manual for Signing and Pavement Marking of the National System of Interstate and Defense Highways*. The manual focused on guidance rather than regulation or warning signs. It introduced the green sign with white wording and the interstate shield.

AASHO Adds a "T"

On March 2, 1966, President Lyndon B. Johnson asked Congress for a Department of Transportation that could coordinate transportation modes. Following congressional approval, President Johnson signed the Department of Transportation Act of 1966 on October 15. The department and the new Federal Highway Administration (FHWA), which was created by the Act, began operations on April 1, 1967. The new Secretary of Transportation, Alan S. Boyd, and his immediate successors, former Administrator Volpe and oil executive Claude S. Brinegar, encouraged the States to create similar departments.

Iowa Director of Highways Joseph R. Coupal, Jr., was on the AASHO special committee that recommended transforming the association into AASHTO. On September 30, 1974, he became Deputy Federal Highway Administrator.

In 1967, New Jersey became the first State to establish a department of transportation. By 1973, 20 States and Puerto Rico had established departments consolidating separate modal agencies under a unified leadership.

In November 1972, AASHO established a special committee to consider a broader mandate. As a member of the committee, Iowa Director of Highways Joseph R. Coupal, Jr., told the annual meeting, "It is imperative that future planning for States and the Nation include the study and appropriate utilization of all modes of transportation." He also recommended that States help "develop new and more efficient systems [that] will reduce pollution and lower the consumption of our energy supply."

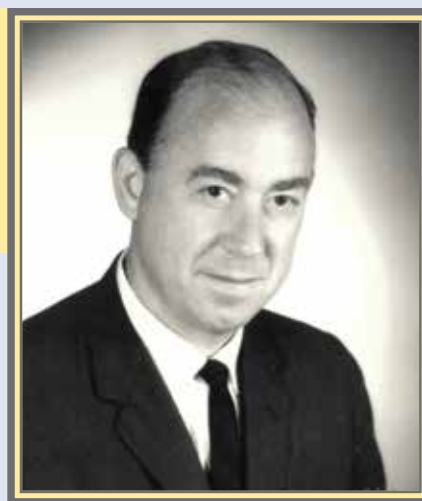
On November 13, 1973, AASHO's Policy Committee approved a new name for the organization, the American Association of State Highway and Transportation Officials, known as AASHTO, and a broadened mission and membership to include all forms of transportation.



The Post-Interstate Era

The longstanding partnership of AASHO/AASHTO and FHWA built the interstate system during years of achievement and controversy. For more information, see articles in the archives of PUBLIC ROADS at www.fhwa.dot.gov/publications/publicroads/past.cfm (such as September/October 2000, March/April 2006, May/June 2006, and July/August 2013).

The Surface Transportation and Uniform Relocation Assistance Act of 1987 (STURAA) was widely perceived as the final bill of the interstate era. It authorized \$17 billion to finish the interstate system. When STURAA became law on April 2, 1987, 97.5 percent of the system was open to traffic:



41,759 miles (67,205 kilometers) of the 42,797 designated interstate miles (68,875 kilometers).

By then, AASHTO had established the 2020 Consensus Transportation Program in February 1987, headed by Director Charles L. Miller of the Arizona Department of Transportation, to consider the post-interstate era. The goal was to identify a strategy that would enable public and private interests to commit to a redirected program that would meet national transportation needs while clarifying the roles of Federal, State, and local agencies well into the 21st century.

AASHTO's efforts led to the establishment of a diverse Transportation Alternatives Group to analyze information gathered during the 2020 program and identify alternative national transportation strategies for the future. Thomas W. Bradshaw, Jr., former secretary of the North Carolina Department of Transportation, chaired the group.

In September 1988, AASHTO's *The Bottom Line: A Summary of Surface Transportation Investment Requirements 1988-2020* documented the need for increased and continuing investment in surface transportation. *New Transportation Concepts for a New Century*, published in December 1988 (and a modified final edition in October 1989), covered the full range of transportation modes. This broad perspective was essential, as the report explained: "It is AASHTO's belief that each transportation system, each mode, must become more and more efficient for the Nation to reach its competitiveness goals."



On March 8, 1990, President George H. W. Bush and Secretary of Transportation Samuel K. Skinner unveiled a new national transportation policy for the post-interstate era. Many of its ideas began with AASHTO's 2020 initiative.

New Transportation Concepts urged the Nation to commit funds to sustain and enhance highways and public transportation. In addition, the publication recommended a two-pronged approach of categorical and flexible programs. The categorical programs "would include a new National Highway System consisting of the Interstate Highway System and a portion of the redefined Principal Arterial System, and major transit systems." The flexible program involved funds to help State and local officials address "such national issues as urban mobility, suburban congestion, rural access, and links between transportation modes."

After *New Transportation Concepts*, the focus shifted to the Transportation Alternatives Group, which released its recommendations in January 1990. Flexibility was the key. The group supported the National Highway System concept, but beyond the routes of national interest, the group recommended that the program should include substantial simplification and increased flexibility and discretion to enable State, regional, and local governments "to more effectively meet specific urban, suburban, and rural transportation needs." Safety, as well as bridge replacement and rehabilitation, should remain priorities. The Transportation Alternatives Group also endorsed measures to increase system productivity through traffic operations, incident management, and surveillance and control techniques.

With regard to funding, the Transportation Alternatives Group called for the Federal Government

to "renew its commitment to a strong transportation program in support of the Nation's economic health and prosperity." It supported continuation of the Highway Trust Fund, but in one of the group's more difficult decisions, it recommended that Federal-aid highway funds should continue to be allocated to the States, thereby rejecting calls from cities for direct allocation of funds.

Now it was up to the Bush Administration and Congress to create legislation for the post-interstate era.

National Transportation Policy

In 1989, President George H. W. Bush appointed Samuel Skinner to be the Nation's 10th Secretary of Transportation. Skinner had been chairman of the Regional Transportation Authority of Northeastern Illinois, a mass transportation district, where he developed a well-received long-range plan for the region's transportation needs.

In 1989, Secretary Skinner initiated a plan to develop a National Transportation Policy, including transportation needs through the year 2050. To head the initiative, he chose Deputy Secretary Elaine L. Chao, who had been Deputy Administrator of the Maritime Administration and chairwoman of the Federal Maritime Commission under President Ronald Reagan, and Federal Highway Administrator Thomas D. Larson. Dr. Larson had helped create the Pennsylvania Department of Transportation in 1970 and served as Pennsylvania's Secretary of Transportation for 8 years. Also, Larson had been active in AASHTO and the Transportation Research Board, serving as president of AASHTO in 1986.

On March 8, 1990, President Bush and Secretary Skinner released *Moving America: New Directions, New Opportunities* during a ceremony in the Old Executive Office Building. Bush called on the private sector to join Federal, State, and local officials in the effort to improve transportation: "Such a partnership has already built a transportation system that is the envy of the world. And if we work together in this joint venture, America can continue to be the world leader in transportation."

The emphasis of *Moving America* was on preserving infrastructure, managing it better, providing a level playing field for transportation choices, enhancing operation through management systems and operational and technological advances, implementing transportation demand management, increasing private sector involvement in financing, providing intermodal and rural connections, and ensuring new capacity for transportation systems.

Although the report did not comment on the National Highway System, one of its strategies was to focus on systems and projects of national significance.

In many ways, *Moving America* was consistent with AASHTO's 2020 initiative. However, the most controversial element of the National Transportation Policy was that it proposed shifting some costs to State and local governments. As AASHTO's then President Kermit Justice of Delaware pointed out, "The road to a sound transportation future cannot be paved with good intentions. It will also take dollars." Congress considered the AASHTO, Bush Administration, and other proposals for the shape of the post-interstate era. The result was the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). ISTEA called on FHWA to work with the States to identify principal arterials for the National Highway System, subject to congressional approval.

The legislation also continued interstate funding through fiscal year 1996, largely because of commitments in STURAA to the Central Artery/Tunnel Project in Boston, MA. In addition, the legislation strengthened the metropolitan transportation planning process to give increased authority to local officials for developing

the best mix of projects to meet their transportation needs.

President Bush signed ISTEA on December 18, 1991, in Tarrant County, TX, on a State Highway 360 construction site not far from Dallas/Fort Worth International Airport. He told the crowd, "The future of American transportation begins today."

After the ceremony, President Bush headed to a nearby hotel to address a special meeting of AASHTO. He urged AASHTO to join with the Department of Transportation in "making sure this money gets to its destination swiftly, gets used wisely, and helps Americans build the foundations for the next American century."

ISTEA, with many of its concepts emerging from AASHTO's post-interstate reviews, was landmark legislation that provided the structure of the Federal-aid highway, transit, and safety programs through the next several reauthorization cycles. (See "Creating a Landmark" in the November/December 2001 issue of PUBLIC ROADS for a more detailed account of the history of ISTEA.)

One Hundred Years Of Service

In addressing AASHTO, President Bush was speaking to an organization that worked closely with FHWA to give the American people a superior, flexible transportation

network. Its predecessor, AASHO, had helped BPR build the first interstate system—a paved, mostly two-lane U.S. highway network. AASHO and its successor, AASHTO, had helped complete the second interstate system in the form of the Dwight D. Eisenhower National System of Interstate and Defense Highways. Now, it helped shape the post-interstate era.

More than two decades after President Bush signed ISTEA on a cold, rainy day in Texas, AASHTO continues to work with the State transportation departments, the U.S. Department of Transportation, and the broader transportation community to, as President Bush put it, create new ways of moving America forward.

One hundred years ago, AASHO helped create the Federal-State partnership that gave the country a highway network that sustains economic development, supports national defense, and is so much a

An Equal Balance

For AASHO's 50th anniversary in 1964, Federal Highway Administrator Rex M. Whitton (1961–1966), former chief engineer of the Missouri State Highway Commission, wrote: "As a State highway department chief engineer, I fretted more than once about what seemed a slow moving and obstinate Bureau of Public Roads. And as Federal Highway Administrator, I have fretted more than once about what seemed a hasty and stubborn State highway department. . . . Perhaps this is as good evidence as any that the Federal-State partnership is in good balance and both parties are doing their best to work together."

part of the daily lives of U.S. citizens that most people take it for granted. In the 21st century, AASHTO continues to work with its partners to ensure that the U.S. transportation network can meet the new challenges of a changing world.

What has not changed during AASHTO's first 100 years is its commitment to partnership, the strength of its leadership, and the important role it plays within the transportation community and on Capitol Hill.

Richard F. Weingroff is the information liaison specialist in FHWA's Office of Infrastructure. After graduating from the University of Maryland with a bachelor's degree in English and completing 4 years in the U.S. Air Force, he joined FHWA in September 1973. As FHWA's self-appointed "unofficial historian," he also oversees FHWA's "Highway History" Web site at www.fhwa.dot.gov/infrastructure/history.cfm.

For more information, contact Richard Weingroff at 202-366-4856 or richard.weingroff@dot.gov.

On June 21, 1991, President George H. W. Bush addressed AASHTO officials regarding the need for reauthorization legislation for the post-interstate era. "No transportation partnership," he said, "has endured so long or accomplished as much as the one between the Federal Government and AASHTO." (L-R): Secretary of Transportation Samuel K. Skinner, AASHTO President Hal Rives (Commissioner, Georgia Department of Transportation), President Bush, Executive Director Ray Chamberlain of the Colorado Department of Transportation, and AASHTO Executive Director Francis B. Francois.

Photo courtesy of AASHTO.



Bracing for Hard Times Ahead

by Robert Kafalenos, Robert Hyman, Rebecca Lupes, and Brian Beucler



What is FHWA doing to prepare the country's transportation system for climate change? Here are tools for assessing and improving the Nation's readiness and resilience.

Although strategies for adapting to weather-related natural hazards should be nothing new to transportation officials, the increasingly alarming information connected to climate change calls for a heightened level of urgency. Rising sea levels and air temperatures are among the disturbing trends.

The rate of change is expected to increase in the coming decades. In 2014, the National Climate Assessment projected that sea levels will rise as

much as 4 feet (1.2 meters) by 2100. Temperatures could rise by 4 degrees Fahrenheit (°F) (2.2 degrees Celsius, °C) in the next few decades and 10 °F (5.5 °C) by the end of the century, depending on emissions of greenhouse gases. The frequency of the strongest hurricanes is expected to increase by the end of the century as well.

The transportation system and its individual assets already are designed to withstand a range of environmental conditions, including extreme weather events. However, climate change adds stressors, such as more frequent and severe storms, that are not fully addressed in current planning and design processes.

Impacts resulting from climate change and extreme weather threat-

en the considerable Federal, State, and local investments in transportation infrastructure. They also jeopardize the transportation community's shared goals of improved safety, system reliability, and asset management.

As Mike Culp, leader of the Sustainable Transport and Climate Change Team at the Federal Highway Administration (FHWA), notes, "The only way we can preserve the state of good repair of our transportation system is to plan for future climate and incorporate certain types of designs or treatments that will help protect the system in the future."

Because of the myriad challenges arising from climate change, FHWA has been studying the impacts on transportation for more

(Above) A storm surge during Hurricane Dennis in 2005 overtopped U.S. 98 near Destin, halfway between Pensacola and Panama City on Florida's panhandle on the Gulf of Mexico. Photo: FDOT.

than a decade. As a result, FHWA is spearheading a number of activities to help its partners—State departments of transportation (DOTs) and metropolitan planning organizations (MPOs)—assess their vulnerabilities and develop policies and strategies to address climate change and extreme weather events by building a more resilient transportation system.

Efforts include developing tools to support activities at the systems level, such as regional and statewide planning and asset management to promote resiliency. The goal is for the transportation network to meet current and future environmental conditions by taking into account climate change risks in all relevant transportation decisions. Other tools support project-level activities, including environmental reviews, preliminary engineering, design, construction, operations and maintenance, and rehabilitation and reconstruction activities.

To date, various initiatives are underway, including two key efforts: a U.S. Department of Transportation (USDOT) Gulf Coast Study and pilot studies of climate resiliency. The latter resulted in the development of a framework for assessing vulnerability to climate change.

The Gulf Coast Study

The first phase of the Gulf Coast Study, completed in 2008 and managed by FHWA in partnership with the U.S. Geological Survey, sought to identify potential vulnerabilities across the coastal region from Houston, TX, to Mobile, AL. The second phase includes development of adaptation options for key, vulnerable transportation facilities in the region.

The project consists of four main tasks: (1) identification of transportation infrastructure considered critical to Mobile, (2) development of information on climate projections necessary to inform transportation decisionmaking at the engineering and operations levels, (3) analysis of vulnerability across the range of critical assets for each transportation mode represented, and

These workers are viewing hurricane damage along Route 35 in New Jersey, one of the States selected by FHWA for a pilot study on the vulnerability of the transportation system.

The Effects of Climate Change

Climate change impacts of concern include rising sea levels, which can affect broad areas and make it difficult to maintain roads and highways. Low-lying and subsiding areas along portions of the Gulf and Atlantic coasts are particularly vulnerable to future sea level rise. In general, concerns include the following:

- Potentially heavier rainfall events
- Stronger hurricanes and the resulting flooding and storm surge and wave impacts, which can damage roadways and bridges and disrupt traffic
- Sea level rise, which can magnify the impacts of other coastal issues, including northeasters on the east coast, hurricanes on the east and gulf coasts, and king tides (the highest tides of the year) on the west coast
- More frequent heat waves and higher summer temperatures, which can stress materials and cause pavement buckling

(4) engineering analysis and development of adaptation options for 11 assets or transportation functions.

Pilot Studies of Resiliency

In addition to the Gulf Coast Study, FHWA has sponsored two rounds of pilot studies that helped the agency develop a framework for the assessment of risk and vulnerability to climate change. The first set of five pilot projects was conducted in 2010 and 2011 by the Metropolitan Transportation Commission in San Francisco, CA, in conjunction with the Bay Area Conservation and Development Commission; the OahuMPO in Hawaii; the New Jersey DOT; together with three New Jersey MPOs; the Virginia DOT; and the Washington State DOT. FHWA used the results of the pilots and other work to develop a *Climate Change & Extreme*

Weather Vulnerability Assessment Framework (FHWA-HEP-13-005).

Although FHWA learned a great deal from the five pilot projects, the following additional needs emerged: paying greater attention to inland areas and moving beyond vulnerability to focus on solutions. To address these needs, FHWA selected 19 additional pilots from a large pool of submissions in 2013. The pilots are scheduled to be completed by early 2015.

Many of the pilots are focused on adaptation, from both programmatic and engineering standpoints. The projects span a range of impacts and cover a broad geographic area. The work of the pilot projects will help further the state of practice in the emerging area of resilience to climate change. After the 19 pilot reports are completed, links to them will be available on the FHWA



North Jersey Transportation Planning Authority

Climate Change Adaptation site at www.fhwa.dot.gov/environment/climate_change/adaptation.

Tools and Guides

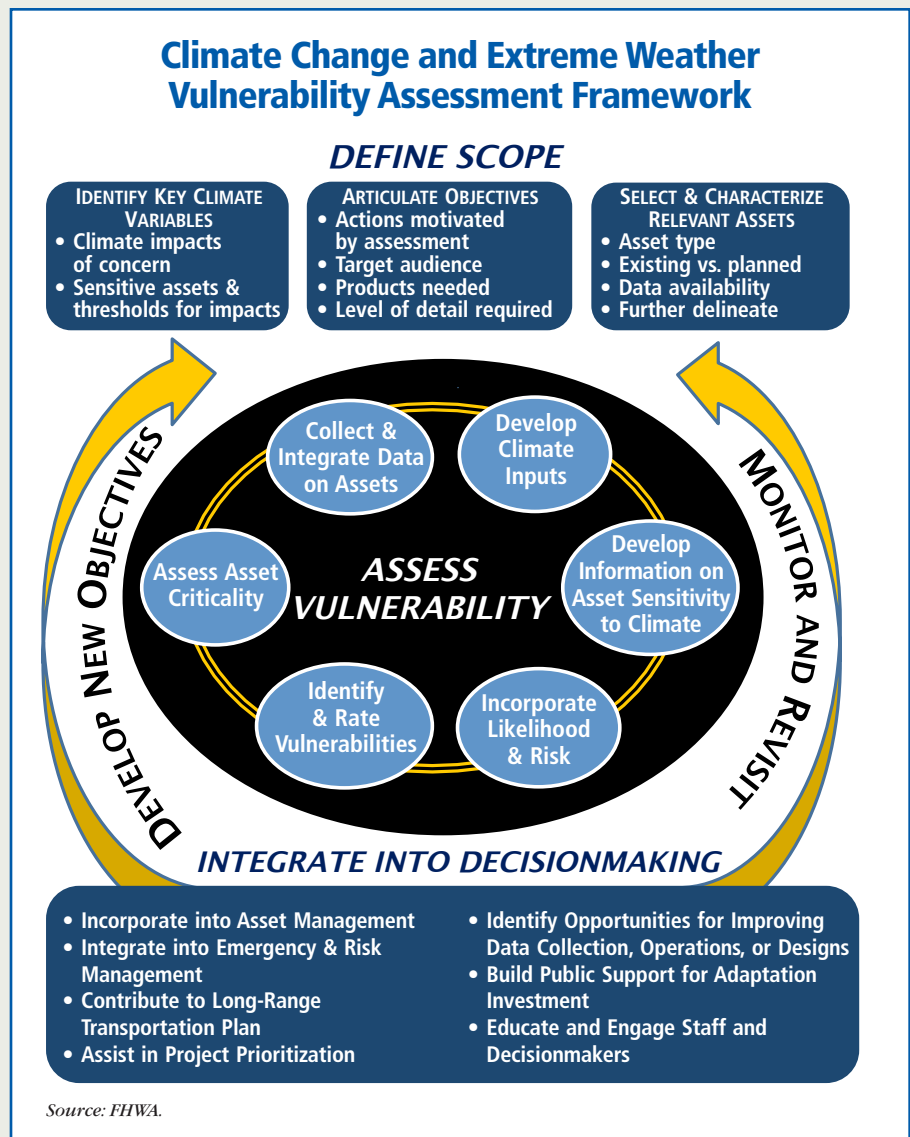
The second phase of the Gulf Coast effort and the five initial pilot projects led to the development of a suite of practical tools to help transportation organizations conduct assessments of vulnerability and develop adaptation strategies. Each of the tools, guides, and procedures is designed to simplify the analysis process.

The first of these tools is an assessment framework that outlines an overall analytical process. The framework largely draws from the experiences gathered from the five pilot projects that FHWA sponsored in 2010 and 2011. It also draws examples from USDOT's Gulf Coast Study and work by other agencies around the country.

The other tools and procedures facilitate additional tasks, such as identifying critical assets and their sensitivity to climate effects, collecting climate information relevant to coastal and inland areas, evaluating and ranking vulnerabilities, assessing project-level vulnerabilities, and developing adaptation options.

Assessment Framework

The Climate Change & Extreme Weather Vulnerability Assessment Framework is a guide for transportation agencies interested in



Climate Resiliency Tools and Guides: An Overview

FHWA has developed, or is in the process of developing, the following products related to climate change. All of the tools will be available on the FHWA Web site at www.fhwa.dot.gov/environment/adaptationframework.

Vulnerability Assessment Framework. The *Climate Change & Extreme Weather Vulnerability Assessment Framework* (completed by FHWA in 2012) is intended for transportation agencies conducting vulnerability assessments. The tool includes discussion, resources, and in-practice examples of the major tasks involved in assessing vulnerability to climate change.

Vulnerability Assessment Scoring Tool (VAST). This Excel®-based tool (with macro-driven user interface) enables users to design and structure an indicator-based vulnerability assessment. Once FHWA completes VAST in the fall of 2014, State DOTs will be able to use it to create a relative vulnerability score for each asset evaluated.

CMIP Climate Data Processing Tool. This large Excel® file processes raw climate data, which users download from a third-party site. Outputs are projected temperature and precipitation changes in a local area. The tool, which was developed by FHWA, provides a relatively quick and easy way for users to determine the poten-

tial magnitude of certain changes in their area. The tool will also be available on FHWA's climate Web site, as will the following FHWA tools:

Procedures for Analyzing Coastal Processes. These procedures and examples provide information on how to develop scenarios for future sea level rise and coastal storms and how to model the resulting impacts.

Engineering Analyses: An 11-Step Process. This assessment process provides a method to analyze the vulnerability of a particular road link, bridge, or other facility to projected changes in climate and develop, analyze, and ultimately select adaptation options.

Assessing Criticality in Transportation Adaptation Planning. This guide helps transportation agencies determine how to focus their vulnerability assessments on the most critical components.

Transportation Climate Change Sensitivity Matrix. This spreadsheet documents how different climate stressors affect several types of transportation infrastructure. The tool contains a macro-based user interface that enables users to generate reports related to specific stressor-asset combinations according to their needs.

evaluating their vulnerability to climate change and extreme weather events. It provides a set of key steps to conduct vulnerability assessments and uses in-practice examples to demonstrate a variety of ways to gather and process information.

Sandy Salisbury, manager of the Roadside and Site Development program at the Washington State DOT, says, “It’s important to do a vulnerability and risk assessment because things are changing. We need to know where we have weaknesses in a system, and we need to be able to look ahead and prioritize where to do work based on what’s vulnerable and what’s critical.”

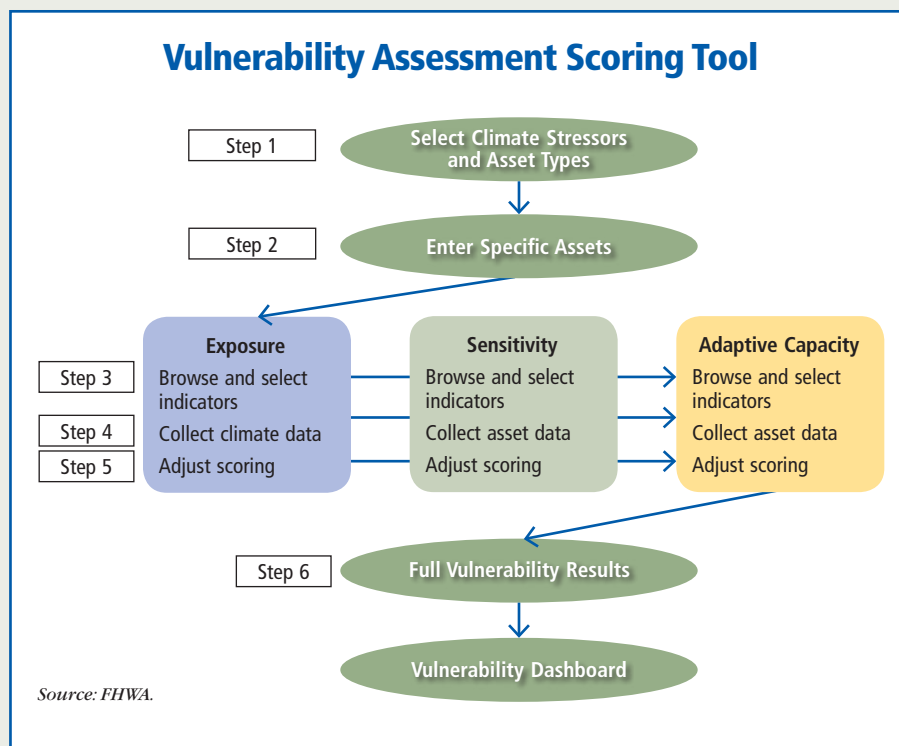
A companion Web site, www.fhwa.dot.gov/environment/adaptationframework, for the assessment framework includes links to additional resources, tools for conducting the assessments, and video interviews with transportation professionals who have undertaken some of the steps.

For the most part, the framework is limited to assessing the vulnerability of the transportation system as opposed to evaluating adaptation options. In the future, FHWA plans to update and expand the resource into a Climate Change Resilience Framework with the results of several studies currently underway or recently completed, including the Gulf Coast Study’s engineering assessments, the 19 climate resilience pilots, and the Hurricane Sandy Follow-up and Vulnerability Assessment and Adaptation Analysis project.

Vulnerability Assessment Scoring Tool (VAST)

Among the results to date, FHWA has developed VAST, an Excel®-based tool, to provide a structured framework for conducting an indicator-based scoring process for State DOTs, MPOs, and other organizations to assess vulnerability to climate change. In other words, VAST helps a user derive a vulnerability score for any given transportation asset at any scale. A road segment, a bridge, or an airport could all be examples of assets.

The user calculates the vulnerability score as a function of exposure, sensitivity, and adaptive capacity. The score is derived from a series of indicators. For instance, the elevation of the deck of a



coastal bridge could be an indicator of the structure’s sensitivity to sea level rise. Similarly, pavement mix and traffic load could be used as indicators of a road segment’s susceptibility to high temperatures.

The VAST tool guides users through several steps: (1) choosing relevant climate stressors to evaluate; (2) selecting exposure, sensitivity, and adaptive capacity indicators; (3) collecting data about climate and assets; (4) developing scoring approaches to convert raw data into scores on a scale of 1 to 4; and (5) reviewing the vulnerabilities identified in the tool. The result is a set of numerical scores that can be used to rank assets by vulnerability.

The tool is designed to be highly flexible. Users can choose from a set of indicators or make their own, and adjust the scoring system based on a variety of factors, such as expert judgment, stakeholder input, or established thresholds. In addition, VAST is designed to be a transparent tool that helps users to decide which factors are most important and then to apply those factors systematically to the data collected.

It is important to understand what VAST does and does not do. VAST *does* provide a structure for users to enter data they have collected and interpret that data to better understand vulnerabilities in their

system. VAST *does not* provide “default” information about particular assets or their vulnerability; instead, the tool relies on input about assets and climate provided by the user.

CMIP Climate Data Processing Tool

The World Climate Research Programme, sponsored by the United Nations, developed the Coupled Model Intercomparison Project (CMIP) as a standard experimental protocol for studying the output of climate scientists’ models that couple the general circulation of the atmosphere and that of the oceans. The CMIP Climate Data Processing Tool is Excel®-based and uses readily available temperature and precipitation projections to calculate variables that can be used to assess the vulnerabilities of transportation infrastructure.

These variables include temperature and precipitation thresholds similar to those used in the second phase of the Gulf Coast Study. Those thresholds are relevant to the design, operation, and maintenance of transportation infrastructure. Examples include the following:

- Average number of days above 95 °F (35 °C), 100 °F (38 °C), 105 °F (41 °C), and 110 °F (43 °C)
- Highest 4- or 7-day average summer temperature

Climate Projection for a Sample Grid Cell

Click column headings for additional info	Baseline (1970–1999)		Mid-Century (2030–2059)				
	Observed Value	Modeled Value	Projected Value	Change from Baseline	% Change from Observed	Model Uncertainty Range (95% Confidence Interval)	
						Low	High
Annual Averages							
Average Annual Mean Temperature	76.1 °F	75.5 °F	77.6 °F	1.6 °F	0%	77.4 °F	77.9 °F
Average Annual Maximum Temperature	83.7 °F	83.5 °F	85.3 °F	1.5 °F	0%	85.0 °F	85.5 °F
Average Annual Minimum Temperature	68.4 °F	67.4 °F	70.0 °F	1.6 °F	0%	69.8 °F	70.2 °F
Annual Extreme Heat							
Hottest Temperature of the Year	94.6 °F	93.0 °F	97.4 °F	2.9 °F	1%	96.9 °F	97.9 °F
“Very Hot” Day Temperature (Very Hot defined as 95 th Percentile Temp)	91.7 °F	90.9 °F	93.9 °F	2.2 °F	0%	93.5 °F	94.3 °F
“Extremely Hot” Day Temperature (Extremely Hot defined as 99 th Percentile Temp)	93.8 °F	92.2 °F	96.2 °F	2.4 °F	0%	95.8 °F	96.6 °F
Average Number of Days per Year Above Baseline “Very Hot” Temperature (91.7 °F)	18.3 days	18.3 days	75.6 days	57.3 days	314%	66.4 days	84.7 days
Average Number of Days per Year Above Baseline “Extremely Hot” Temperature (93.8 °F)	3.7 days	3.7 days	43.0 days	39.4 days	1,074%	33.2 days	52.9 days
Average Number of Days per Year above 95 °F	1.3 days	0.0 days	6.0 days	4.8 days	375%	3.5 days	8.5 days

- Largest 3-day rainfall event per season
- Very heavy 24-hour precipitation amount

The CMIP tool includes instructions for how to download the data and calculate the projections for up to four grid cells. Climate scientists divide the earth's surface into grid cells, then calculate projections of future conditions for those cells, and average them for two future time periods—midcentury and end-of-century. Although climate models can produce values down to as short as a day, it is important to consider average values over a minimum of 20 years when projecting future climate conditions, because climate is defined as the average of weather over a minimum of several decades.

The data are housed on a site hosted by the U.S. Bureau of Reclamation and other organizations and Federal agencies. The site hosts two versions. The first is based on CMIP phase 3 projections used in the United Nations' Intergovernmental Panel on Climate Change's (IPCC) *Fourth Assessment Report* (2007) and *Global Climate Change Impact in the United States* (2009). The other version relies on the CMIP phase 5 dataset from the *National Climate Assessment* (2014) and the IPCC's *Fifth Assessment Report* (2013–14).

The CMIP datasets include both historic, monitored information for

daily minimum and maximum temperature and daily precipitation, and projections of these values from a range of scenarios for greenhouse gas emissions. The CMIP projections statistically downscale projections from global climate models, which are produced at a scale of roughly 100 kilometers by 100 kilometers or more, to a spatial resolution equivalent to roughly 7.5 miles (12 kilometers) by 7.5 miles or 56 square miles (145 square kilometers).

The downscaling process relies on relationships evident in past precipitation and temperature data between the two scales (and assumes that they will remain constant over time). Climate scientists apply those statistical relationships to future

global climate model projections to develop projections at the smaller scale. (For more information, see the two reports produced as part of Gulf Coast Study phase 2, task 2, available at www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/phase2_task2.)

Rob Graff, manager of the Office of Energy and Climate Change Initiatives at the Delaware Valley Regional Planning Commission (DVRPC), notes that the tools have been designed with the end user in mind. He says, "The CMIP Climate Data Processing Tool enables the user to quickly access and process the full range of climate projections available from the CMIP database, which

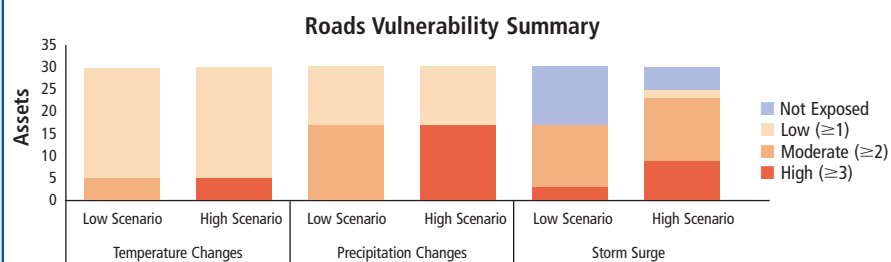
Sample Screen from the Results Dashboard

Vulnerability Assessment Summary

View results for . . .

Roads

Generate PDF



This screen shot from FHWA's VAST tool shows the number of assets (in this case, roads) in various scenarios with vulnerability scores at low, moderate, or high levels, or no exposure. Source: FHWA.

can save considerable time and money for an MPO or other users.”

Procedures for Analyzing Coastal Processes

Regarding coastal processes related to climate change, such as local sea level rise and storm surge and wave action caused by coastal storms, FHWA provides procedures and guidance via two major sources: the second phase of the Gulf Coast project in Mobile and a new hydraulic engineering circular, *Highways in the Coastal Environment: Assessing Extreme Events* (HEC-25 Volume 2).

The second task of the Gulf Coast phase 2 study examined climate-related coastal stressors using a scenario approach that looked at combinations of various sea level rises with a select group of coastal storms (hurricanes). The scenarios were tied to sea level increases of just under 1 foot (0.3 meter) in 2050, and moderate and high projections of almost 2.5 feet (0.75 meter) and more than 6.5 feet (2 meters), respectively, in 2100. Although sea level rise may be relatively small, it can amplify the impacts of coastal storm surge and wave action.

The scenarios were based on two historical storms that damaged Mobile: Hurricanes Katrina in 2005 and Georges in 1998. Because impacts are sensitive to parameters such as sea level, wind speed, barometric pressure, and storm track, the researchers adjusted the variables in the historical storms to look at a range of plausible “what if” scenarios of inundation and damage.

Although the researchers assigned no probabilities of occurrence to the scenarios, the analysis provides a range of calculated degrees of impact to guide planning by a community. Given the large amount of uncertainty associated with predicting when and to what magnitude climate change will affect coastal processes, many communities are choosing to select one or two future scenarios to plan for and will likely revisit these in the near future as trends emerge more clearly and climate science improves.

HEC-25 Volume 2, released October 2014, provides technical guidance on a national scope for assessing the vulnerability of coastal highways to extreme events and climate change. The document fo-

Rock scaling and slope stabilization on U.S. 12 in the vicinity of White Pass in Washington State will reduce the potential for future rockslides. Increases in precipitation tied to extreme weather and climate change can increase dangers to the traveling public posed by landslides.



Washington State DOT

cuses on quantifying exposure to sea level rise, storm surge, and waves when considering climate change.

It identifies critical coastal processes and unique phenomena (for example, tides, tsunamis, bluff erosion) specific to regional shorelines of the United States, including the Great Lakes. It also provides an example of how to project future sea level rise for any location tied to tidal gauges around the country.

Depending on the resources available to an individual community and the degree of precision desired, local decisionmakers might choose any of three suggested levels of effort for conducting vulnerability assessments. The document provides case studies to illustrate those levels of effort. The first level involves the use of existing floodplain maps with no computer modeling. The second level includes computer modeling of surge and wave fields for specified storm and climate change scenarios. Level 3 is similar to level 2 but characterizes exposure in terms of probability and risk, and assigns unique probabilities to the scenarios.

Jurisdictions may also benefit from the brief discussion of adaptation options, from protection with hard structural solutions and soft nonstructural solutions, to relocation and strategies of planned retreat.

Engineering Analyses: An 11-Step Process

The FHWA researchers applied the following 11-step process in engineering analyses in the Gulf Coast Study. In addition, they are using similar analytical frameworks in two other FHWA studies: *Hurricane Sandy Follow-up and Vulnerability*

Assessment and Adaptation Analysis (expected publication 2015) and the *Transportation Engineering Approaches to Climate Resiliency* (expected publication 2016), as well as in some of the ongoing pilot projects that will be completed in 2015.

1. *Describe the site context*, including location-specific details, such as surrounding land uses, population, and economic activities; performance characteristics of the transportation network; environmental resources; and long-term transportation and land use plans. Also include the function(s) of the transportation facilities and whether they take climate change impacts into account.
2. *Describe the existing or proposed facility*, including location, functional purpose, design type, dimensions, elevations, design life, age, and condition.
3. *Identify climate stressors that might impact infrastructure components*, such as variables that would typically be considered in the planning and design of the subject facility (for example, precipitation, temperature, sea level, storms).
4. *Decide on climate scenarios and determine the magnitude of the changes*. Describe the climate model projections used to determine whether and how much each of the variables of concern might change in the future.
5. *Assess the performance of the existing or proposed facility* today under current climate conditions and in the future under each of the possible

future climate scenarios selected in step 4.

6. *Identify adaptation option(s).* Describe potential planning or design-oriented options that could be used to address climate risks to the facility.
7. *Assess the performance of the adaptation option(s)* under each potential climate change scenario selected in step 4. This analysis is similar to step 5, except that it is performed on the adaptation options applied to the existing facility as opposed to the existing facility without those adaptations, or in the case of new facilities, the standard design without adaptations.
8. *Conduct an economic analysis.* Evaluate how the benefits of undertaking a given adaptation option, defined as the costs avoided because of the adaptation, compare to its incremental costs under each of the possible future scenarios developed in step 4.
9. *Evaluate additional decision-making considerations*, including other (nonengineering, noneconomic) factors that should be considered before a final decision is reached.
10. *Select a course of action* after considering both economic and noneconomic factors, weighing all of the information presented.
11. *Plan and conduct ongoing activities*, including monitoring, using tools such as facility management plans.

Next Steps

In addition to these tools, FHWA has developed two others to guide the user in analyzing the criticality and sensitivity of transportation facilities. The criticality tool—Assessing Criticality in Transportation Adaptation Planning—provides information on how to design and focus an assessment of criticality to meet the needs of the ultimate user or audience. It also summarizes the approach used in the Gulf Coast 2 study and several of the adaptation pilot studies, as well as the range of criteria used.

The Transportation Climate Change Sensitivity Matrix is a tool that helps

the user understand how different asset types across transportation modes can be affected by a range of climate stressors. DVRPC's Graff says, "The Transportation Climate Change Sensitivity Matrix is an excellent compendium of information that summarizes the climate stressor/infrastructure relationships for multiple climate stressors and types of infrastructure. It is a great tool for helping planners and engineers begin to talk about potential vulnerabilities."

Many of the tools and guides resulted from projects conducted by FHWA, USDOT, and their partners. In addition, FHWA has a range of ongoing activities designed to provide further information to help transportation agencies understand the risks posed by future extreme weather events and climate change, and provide guidance on how to counter these risks. These ongoing activities include the second round of 19 climate resilience pilots, the *Hurricane Sandy Follow-up and Vulnerability Assessment and Adaptation Analysis*, and a new effort focused on project-level engineering analyses.

Robert Kafalenos is an environmental protection specialist on FHWA's Sustainable Transport and Climate Change Team in the Office of Planning, Environment & Realty. He holds a bachelor's degree in Chinese language and literature from the University of Kansas and a mas-

ter's degree in resource economics and policy from Duke University.

Robert Hyman is also an environmental protection specialist on the same FHWA team. He holds a bachelor's degree in earth and planetary sciences from Harvard University and master's degrees in civil and environmental engineering and in technology and policy from the Massachusetts Institute of Technology.

Rebecca Lupes is another environmental protection specialist on the same FHWA team. She holds a bachelor's degree in economics from Cornell University and a master's degree in resource economics and policy from Duke University. She manages FHWA's climate resilience pilot effort.

Brian Beucler is a hydraulic engineer with FHWA's Office of Bridges and Structures. He holds a bachelor's degree in civil engineering from the University of Virginia and a master's degree in civil and environmental engineering from The George Washington University.

For more information, please visit the FHWA adaptation Web site at www.fhwa.dot.gov/environment/climate_change/adaptation or contact Robert Kafalenos at 202-366-2079 or robert.kafalenos@dot.gov. Or email robert.hyman@dot.gov, rebecca.lupes@dot.gov, or brian.beucler@dot.gov.



North Jersey Transportation Planning Authority

The flooding of this neighborhood in Wayne, NJ, followed Hurricane Irene.



What do you do, when, in the blink of an eye, a major interstate and freight corridor on the west coast is severed? Learn from Washington State's experience.

Surviving an Interstate Bridge Collapse

by Jeffrey L. Horton

(Above) This north main through-truss span of the Skagit River Bridge in Mount Vernon, WA, collapsed into the river after a southbound combination vehicle with an oversized load struck elements of the bridge.

On May 23, 2013, around 7 p.m. Pacific daylight time, a 160-foot (49-meter)-long section of the Skagit River Bridge on I-5 in northwestern Washington State came crashing down into the river below. A combination vehicle hauling a permitted oversized load and traveling southbound over the bridge had struck the northern portal and several overhead sway braces, collapsing the northern span of the through-truss in its wake.

The combination vehicle managed to continue across the bridge, but a southbound pickup truck towing a trailer and a northbound car were not so fortunate. Both vehicles, along with the collapsed span, fell into the river below. Miraculously, no fatalities and only minor injuries resulted. Equally



WSDOT

This aerial view looking east shows the Skagit River Bridge with the collapsed northern span of the through-truss section of the bridge (at left). In the background is the Riverside Drive Bridge, which was the primary detour for I-5 traffic after the collapse.

amazing was that so few vehicles were affected because the collapse occurred the Thursday before Memorial Day weekend, one of the busiest travel weekends of the year.

For oversized loads, such as the one in this case, the carrier is required to obtain a permit through a self-issuing process. The carrier also is required to check restrictions on the route prior to moving. In this case, when the permitted oversize load struck the bridge, it was over the lane marker of the southbound right lane where vertical clearances were lower due to the parabolic shape of the overhead portal and sway brace.

The I-5 Skagit River Bridge is 48 miles (77 kilometers) south of the U.S.-Canadian border and serves as a key connection for traffic and commerce between Seattle, WA, and British Columbia, Canada. In 2012, nearly \$14 billion in U.S.-Canadian

trade and, based on the average daily traffic of approximately 71,000 over the bridge, approximately 26 million vehicle trips crossed the bridge. In addition, I-5 is the only north-south interstate that runs through Washington State.

Both northbound and southbound lanes of I-5 cross the Skagit River on a single bridge. So when the span collapsed, the effects were far reaching. For example, trucking companies that transport goods locally and regionally were unable to move their goods. Many indirect consequences resulted, too. Businesses that rely on customers traveling in the corridor lost business due to the closure and resulting congestion from detoured traffic. Shippers, tourists, shoppers, and recreational users also had to reroute, reschedule, or cancel their trips.

Prompt emergency response followed by swift action and collabo-

ration among multiple agencies was imperative in order to reconstruct the bridge, return traffic to I-5, and get the region back up and running.

Coordinating a Response

Immediately following the collapse, the Washington State Department of Transportation (WSDOT) partnered with the Skagit County Department of Emergency Management, the Washington State Patrol, the U.S. Coast Guard, Naval Air Station Whidbey Island, and the cities of Burlington and Mount Vernon to secure the scene, which included rescuing the vehicles and motorists in the river and establishing initial detour routes for I-5 traffic. WSDOT mobilized bridge engineers and inspectors to assess the damage. WSDOT also worked to provide frequent updates and travel alerts to the media to keep the public informed.

As word about the collapse spread, staff at the Federal Highway Administration (FHWA) Washington Division mobilized to respond to the emergency. The division's bridge engineer, construction engineer, and

the emergency relief program manager developed FHWA's response plan, and the division administrator kept leadership at FHWA headquarters informed about response efforts.

"The team we have here in Washington epitomizes FHWA's response to emergencies," says Dan Mathis, administrator of the Washington Division. "They launched into action quickly upon learning of the Skagit River Bridge collapse and stepped up on behalf of the agency to respond."

FHWA Washington Division staff immediately reached out to WSDOT, offering assistance and opening dialogue between the two agencies. FHWA also began gathering the necessary documentation and information on the history of the structure.

WSDOT's Emergency Operations Center also contacted the FHWA emergency coordinator liaison, who prepared a situation report and worked side by side with WSDOT staff at the emergency center. In addition, within 2 hours, FHWA had deployed staff to the scene of the incident to meet with WSDOT staff.

FHWA staff members worked well into the night collecting data on the bridge, such as its Structure Inventory and Appraisal Sheet from the National Bridge Inventory, structural plans, and inspection history. The team pulled together technical specialists from around the country and participated in conference calls with WSDOT and FHWA leadership. The compiled information would help to brief the National Transportation Safety Board (NTSB) team who arrived onsite the next day.

As with any significant highway incident, NTSB launched an investigation into the probable cause of the collapse and later issued safety recommendations. The report issuing the recommendations is available at www.nts.gov/doclib/reports/2014/HAR1401.pdf. WSDOT opened a dialogue with the FHWA division emergency relief program manager and both began drafting requests for Federal Emergency Relief funding.

By the following day, FHWA division staff members were onsite meeting with the NTSB team to determine additional needs for the investigation. A representative from FHWA's Office of Bridges & Structures accompanied NTSB to

provide additional technical expertise. FHWA also continued to provide assistance to WSDOT staff to quickly move through the process.

Detours and Next Steps

WSDOT established two detour routes. The primary detour routed northbound I-5 traffic east on SR-538 at exit 227 then north on Riverside Drive in Mount Vernon. Traffic crossed the Skagit River on Riverside Drive and entered the city of Burlington on Burlington Boulevard where the detour continued north to George Hopper Road. Once at George Hooper Road, the detour directed traffic west to rejoin with I-5 at exit 229. For southbound traffic, the detour was in the reverse direction along the same route. The detour added only a half mile (0.8 kilometer) of additional travel.

A secondary detour routed southbound traffic off of I-5 at exit 230 onto SR-20, then west to Avon Allen Road and south toward SR-536. At SR-536, the detour directed traffic east where it crossed the Skagit River over a narrow truss bridge and wound through downtown Mount Vernon to rejoin I-5 at exit 226. For northbound traffic, the detour was in the reverse direction along the same

route. The secondary detour added 3 miles (4.8 kilometers) of travel.

The detours posed a number of challenges for travelers and the affected communities. Riverside Drive and Burlington Boulevard are commercial corridors, so posted speeds were slow and the roads were heavily congested with the unanticipated I-5 traffic. The congestion would pose challenges for both communities, prompting Washington State Governor Jay Inslee to secure economic support for several businesses that experienced related hardships.

With the challenges of the detours immediately apparent, WSDOT began the arduous task of figuring out how to fix the collapsed span and return traffic to I-5 as quickly as possible. Since the I-5 Skagit River Bridge's construction in 1955, the structure had not been rebuilt or rehabilitated.

The 1,112-foot (339-meter)-long, 12-span bridge had 4 steel through-truss spans in the main unit and 8 concrete approach spans (4 at each end of the main spans). These 12 spans carry 4 lanes of I-5 traffic on 2 northbound lanes and 2 southbound lanes separated by a concrete median barrier. The overall width of the bridge deck is 60



This combination vehicle with a permitted oversize load is the one that struck the through-truss bridge and caused its collapse. (Inset) The closeup shows the damage to the upper front right corner of the load where it struck the overhead bridge elements.



Here, a crane hoists a pickup truck from the river. The truck plunged into the water when span 8 of the bridge collapsed.

WSDOT

feet (18.2 meters) with a roadway width of 56 feet (17 meters).

The span that collapsed was span 8, the northernmost through-truss span. Each through-truss span (spans 5, 6, 7, and 8) is a simple, independent span measuring 160 feet (49 meters) in length. When span 8 collapsed, the adjacent spans of the through-truss bridge remained in place because of their independent design. With that in mind, the specific challenges WSDOT faced were to remove the collapsed span and replace it. WSDOT also had to address some damage to an overhead sway brace on span 7, which it did in addition to the work on span 8.

Using emergency contracting methods, WSDOT hired a contractor within 24 hours to remove the collapsed span from the river and also to provide input as WSDOT developed a plan of action to get the bridge back into service.

Selecting a Course of Action

Discussion about the best and quickest fix began as early as the night of the collapse. WSDOT recognized early on that the detoured traffic was resulting in negative economic impacts to both Burlington and Mount Vernon, prompting urgent discussions to develop an action plan. Multiple meetings were held throughout the holiday weekend to discuss various options for rebuilding the span and

restoring function to the structure. Attendees included staff from FHWA; WSDOT's Bridges and Structures Office, Maintenance Operations Office, Construction Office, and the Northwest Region and Mount Baker Area offices; and WSDOT Secretary of Transportation Lynn Peterson.

Although the participants evaluated several possibilities, the decision came down to two options: (1) Keep traffic detoured and install a permanent replacement as quickly as possible, or (2) install a temporary span and return traffic to I-5, and then follow with a permanent span at a later date. WSDOT considered both options seriously.

The department attempted to find existing bridge beams that would work for immediate installation of a permanent replacement span rather than having beams fabricated, which

would take too much time. WSDOT located some beams at a fabrication plant in Oregon. However, although the beams were the correct size to carry the required loads, they were not the correct length and did not have the appropriate camber, so time-consuming modifications would have been required.

The second option was to install a temporary span while a permanent replacement span was fabricated. One advantage of installing the temporary span would be to quickly relieve the negative impacts on the local communities as a result of the heavily traveled detours.

After gathering input from Governor Inslee, FHWA, and the contractor, WSDOT elected to proceed with installing a temporary replacement span first and following with a permanent replacement span later. On May 26, Governor Inslee announced the plan to replace the collapsed portion of the bridge. The Governor also challenged WSDOT to install the temporary span by mid-June, followed by the permanent span in mid-September.

Returning Traffic to I-5

Before WSDOT could install the temporary span, the contractor had to remove the collapsed span carefully from the river under the direction of NTSB. Because the incident was under investigation, the debris was treated

The temporary spans are shown here during installation.



WSDOT

as evidence and was removed slowly to preserve its integrity.

On June 5, NTSB completed its onsite investigation and released the site to WSDOT. While the NTSB investigation continued offsite, the contractor completed the removal of all of the debris from the river bottom by June 7.

For the temporary replacement span, the department elected to use two Acrow spans placed side by side. The temporary spans are modular steel prefabricated sections, which WSDOT assembled on the adjoining approach spans of the Skagit River Bridge and launched over the gap. Each of the temporary replacement spans had a width of 24 feet (7.3 meters) and carried two lanes of traffic.

The emergency contractor procured the temporary spans and began assembly on May 28. Working around the clock, WSDOT and its contractor installed the temporary spans and reopened the Skagit River Bridge to traffic on June 19—just 27 days after the collapse.

Although the temporary replacement spans enabled traffic to return to the interstate, they were not ideal. Because of the narrow width of the lanes and the need to reduce truck

impact loadings, all oversize loads were required to use the detours, and the speed limit was reduced to 40 miles (64 kilometers) per hour in the vicinity of the bridge.

Even with the reduced speed limit and load restrictions, reopening the bridge with the temporary spans was an improvement over the detours. According to Jay Drye, then the acting assistant regional administrator for the WSDOT Northwest Region, “Restoring I-5 and getting traffic back onto the interstate was a tremendous relief to the communities, the businesses, and the travelers,” he says. “It was a challenging time for all the people affected. The temporary bridges provided much-needed relief as we went into the summer travel season.”

A Permanent Fix

Shortly after work began on the temporary span, WSDOT switched its focus to developing a plan for the permanent replacement span. To take advantage of contractor ingenuity and efficiency, WSDOT elected to proceed with a design-

build method for project delivery. Instead of designing the replacement span, assembling plans, and advertising the project for bid, WSDOT would provide a framework, design parameters, and time expectations, and select a design-build team based on best value to design and then construct the span.

For the permanent span, WSDOT considered three options: a truss span similar to the original span; prestressed concrete girders with a concrete deck; or steel girders with a concrete deck. Although a truss span would have matched the existing spans, WSDOT determined that fabricating and installing it would take too long to meet the mid-September goal. So WSDOT officials decided to use either prestressed concrete girders or steel girders supporting a concrete deck.

On May 30, WSDOT informed FHWA of its intent to use the design-build contracting method for the permanent span. In the following days, WSDOT developed a request for proposals (RFP) and made it available to six short-listed

WSDOT was able to reopen I-5 to traffic once these temporary Acrow replacement spans were in place.



WSDOT



The design-build team constructed the permanent replacement span on a work platform (right) next to the temporary side-by-side spans (left).

design-build teams. FHWA worked with WSDOT during the development of the RFP and approved it for release on June 3 with a proposal deadline of June 17.

The design-build teams were required to submit a proposal with a cost that included construction of the span to meet the criteria established in the RFP, a plan to minimize impacts on the traveling public during construction, and a timetable for opening the span to traffic no later than October 1, 2013.

Four teams submitted proposals. Two proposed a prestressed girder span, and two proposed a steel girder span. The winning proposal included constructing a prestressed concrete girder span at a cost of \$6.8 million and closing I-5 for only 12 hours to install the permanent span. The contract was executed on June 18, and the notice to proceed was issued on June 19, the same day that traffic was restored to I-5 on the temporary spans. Work on the permanent replacement span began immediately.

Constructing the New Span

The design of the permanent span was completed on July 9, and the next step was to construct it. The design-build team installed a temporary work platform just west of the temporary span, where the team would build the permanent span. When the permanent span was com-

pleted, the team would detour traffic, pick up and slide out the temporary spans, pick up and slide the new permanent span into place, and then reopen the bridge to I-5 traffic.

To begin, the design-build team drove a number of temporary piles into the river on both sides of the span. On the west side it assembled the temporary work platform to construct the permanent span. East of the bridge, it assembled a second temporary platform to hold the temporary spans when it was time for installation of the permanent span.

The permanent replacement span consists of eight 65-inch (1.6-meter)-deep prestressed lightweight concrete bulb-tee girders with a silica fume concrete overlay. The lightweight concrete is a significant design element because the new span is set on the existing bridge substructure. To avoid additional seismic inertia loads, the weight of the permanent replacement span could not exceed that of the original truss span by more than 5 percent. The lightweight concrete used in the girders, the diaphragms, and the bridge rail kept the dead load within that limit.

These elements were constructed on the west work platform using cranes located on the river's north bank and a barge. In spite of the complexity of building the permanent span over the river, the design-build team

was ready to put the finishing touches on it by mid-September.

On the night of Saturday, September 14, the team detoured traffic and closed I-5 at the bridge at 7 p.m. The design-build team then moved the two temporary spans to the platform east of the bridge using hydraulic jacks to slide them on Teflon® pads on long steel rails. Next, the team used a similar system to slide the permanent 900-ton (816-metric ton) span into its permanent location.

The transition took 19 hours and encountered some minor complications, such as an unexpected and time-consuming process to cut through thick metal plates in order to lift the temporary span. However, once the permanent span was in place, the design-build team completed the final roadway striping and cleanup to open the roadway to traffic at 2 p.m. on September 15—only 115 days after the collapse.

Mitigating Structural Risk

Even though the permanent replacement span was in place, work on the Skagit River Bridge was not complete. An analysis of the remaining truss structure, performed while the permanent span was being fabricated, revealed that the bridge was still vulnerable. When span 8 collapsed, the north portal also came crashing down. In addition, the overhead sway braces on the remaining truss spans continued to be a potential obstacle for vertical clearance outside of the lanes. Before oversize vehicles could once again traverse the bridge safely, WSDOT chose to replace the north portal, modify the parabolic sway braces, and modify the south portal.

WSDOT awarded a \$2.7 million project to complete the needed modifications to the remaining truss spans. On Tuesday, September 17, the contractor began additional overnight closures of I-5 at the Skagit River to complete the retrofitting work. The retrofitting crew raised

and reinforced the bridge's overhead structural support system to provide for 18 feet (5.5 meters) of vertical clearance across the remaining spans. In addition to the overhead work, they completed some maintenance work on the rivets below the bridge deck, along with some painting. With the exception of painting the repaired or modified areas, the work for this phase was completed by mid-November. The painting was completed on July 19, 2014.

Emergency Response Funding

To date, the total cost to restore the Skagit River Bridge to full operation is approximately \$20 million. Even though this emergency was not caused by a natural disaster (such as a flood, earthquake, hurricane, or landslide), the majority of the costs to repair the bridge were eligible for reimbursement with FHWA Emergency Relief funds.

Congress authorized the Emergency Relief Program in Title 23, United States Code, Section 125, to provide funds from the Highway Trust Fund for the repair or reconstruction of Federal-aid highways and roads on Federal lands that suffered serious damage from natural disasters or catastrophic failures from external causes. Emergency Relief funds can

supplement resources from States, localities, and other Federal agencies to help in the repair of facilities damaged by eligible events.

The collapse of span 8 of the Skagit River Bridge was viewed as a catastrophic failure prompted by an external cause. Title 23 Code of Federal Regulations (CFR) 668.103 defines a catastrophic failure as the sudden failure of a major element or segment of the highway system because of an external cause such as a barge striking a bridge pier causing the sudden collapse of the structure, a truck crash resulting in a fire that damages the roadway, and acts of terrorism that result in structural damage to the highway facility.

From the beginning, the FHWA Washington Division treated the emergency as an eligible event. On May 24, Governor Inslee declared a state of emergency. The declaration along with a letter of intent was sent to FHWA. FHWA responded to WSDOT with a letter of acknowledgement and eligibility. Through a formal request for Emergency Relief funds, FHWA announced a quick release of \$1 million for the Skagit River Bridge.

Although not all of the expenses were eligible, Emergency Relief funds reimbursed WSDOT and other agencies for their eligible expenses and efforts to correct

the situation. FHWA Emergency Relief funds covered nearly \$18 million of the total expenses.

"The quick release of Emergency Relief funds enabled WSDOT to completely focus on initially mobilizing resources without the burden of trying to determine how to cover the significant costs required to maintain traffic safety and establish alternate routes to keep traffic moving," says John Jeffreys, Federal-aid planning manager with WSDOT. "Throughout the entire event, the responsiveness and cooperation WSDOT received from the FHWA [Washington] Division Office was outstanding and contributed greatly to the reopening of the I-5 Skagit River Bridge just 27 days after the bridge collapsed."

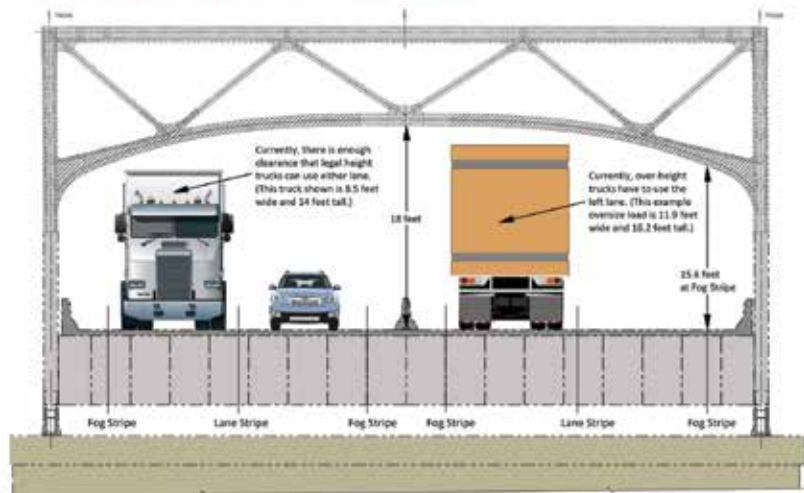
Innovations in Action

Several innovations led to the successful handling of the emergency and the restoration of the Skagit River Bridge. The use of design-build contracting to deliver an Emergency Relief project was a first for WSDOT. Design-build contracting enabled WSDOT to tap into the creativity and efficiency of the contracting community. As time was of the utmost importance, giving the design-build teams the opportunity to design a new permanent replacement span that could be constructed and installed quickly

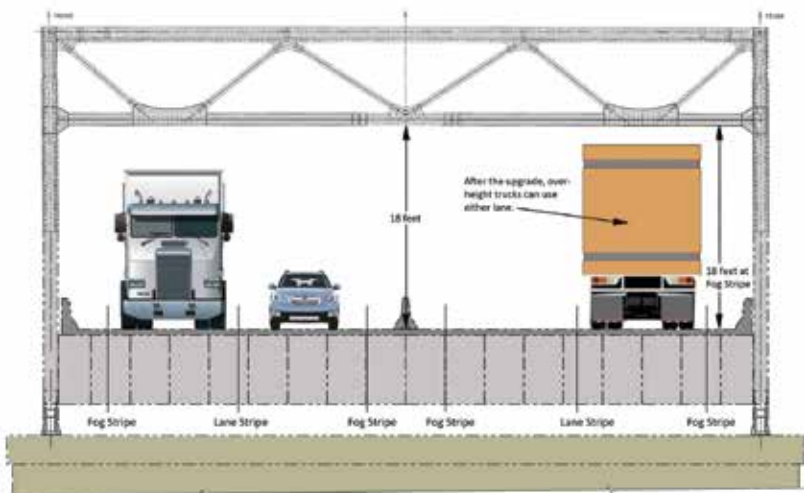
During an overnight closure, the design-build team removed the temporary spans and slid the permanent span into position, as shown here.



Skagit River Bridge - vertical clearance upgrade



Before Upgrade



After Upgrade

This illustration depicts the modification necessary to raise the overhead sway braces of the main truss span to an 18-foot (5.5-meter) vertical clearance across all travel lanes. Source: WSDOT.

and cost-effectively, allowed for the restoration of all traffic to I-5 only 115 days after the collapse.

WSDOT's use of lightweight aggregate in the concrete beams, deck, and barriers made it possible to keep the span's weight within the allowable loads on the existing bridge substructure. This innovation also made the replacement span light enough to be lifted off the work platform and slid into its permanent location.

The slide-in methodology used to construct and move the permanent span into place is an accelerated bridge construction technology being promoted by FHWA's Every

Day Counts initiative. This technology enabled interstate traffic to use the temporary spans while the permanent span was constructed on a temporary work platform. It also minimized traffic disruptions, as the permanent span was slid into place in less than 24 hours. Traditional methods of construction would have taken several weeks while traffic remained detoured through congested city streets.

Another innovative solution was WSDOT's use of the temporary spans on the interstate, which was a first for the department. Although there were load restrictions in place for the temporary spans, this

was an emergency and restoring traffic to I-5 was a high priority.

On September 6, WSDOT and FHWA hosted a showcase in Bellevue, WA. The showcase highlighted the project's use of the accelerated bridge construction technology, underscoring the important effect this technology has had at a national level through Every Day Counts. The showcase also included a project overview, discussions on emergency response, the development of design-build contracts, and the design and construction of the permanent replacement span. An open panel forum discussion offered participants a chance to ask questions. The participants also had an opportunity to attend an onsite tour of the project.

MAP-21 at Work

The passage of the Moving Ahead for Progress in the 21st Century Act (MAP-21) facilitated a few more "firsts" for WSDOT on Emergency Relief projects.

For example, WSDOT added additional train service around the collapsed bridge to help relieve some of the detour congestion. Section 1107 of MAP-21 allows such additional transit service to be eligible for Emergency Relief funding. Prior to MAP-21, that was not possible. WSDOT took advantage of the change.

MAP-21 also expanded the actions that could be categorically excluded from requiring a National Environmental Policy Act environmental impact statement under Title 23 CFR 771.117(c)(9). The expanded actions include the repair or reconstruction of any road, highway, or bridge damaged by an emergency that is declared by the Governor of the State, and the repair or reconstruction activity occurring within the existing right-of-way and in a manner that substantially conforms to the preexisting design, function, and location as the original. This project met those requirements and was categorically excluded. This was the first permanent repair project in Washington State and the Nation that took advantage of this flexibility allowed for Emergency Relief projects.

Collaborating to Meet Goals

Several actions contributed to the successful delivery of this project and communication was key. From



Here, vehicles travel underneath the modified portals and sway braces of the main truss spans after completion of the clearance upgrade project.

the beginning, staff from the FHWA Washington Division and WSDOT held frequent (daily or even multiple times a day) conference calls. The continuous communication kept all parties informed and up to date, which made it possible to find a solution that was acceptable to both WSDOT and FHWA.

"It's all about relationships," says FHWA's Mathis. "The relationship we have with WSDOT allows us to work as a team to do what's best for the traveling public."

One of the best examples of the success of these collaborative efforts is the speed at which WSDOT was able to develop the RFP for the permanent repairs. WSDOT assembled the RFP over a weekend because the RFP writers and reviewers, including FHWA, were all working together at the local WSDOT area office. After the technical specialists developed a section, they forwarded it to the RFP writers and reviewers who edited the language as necessary. Everyone was committed to working long hours to prepare the document quickly. To their credit, it was completed on time.

"The success of the rapid assembly of the Skagit River Bridge

emergency design-build contract package hinged on several indispensable factors," says Derek Case, then the engineering manager for the Skagit River Bridge emergency design-build project. "One, subject matter experts for the key areas—structures, foundations, geotechnical, traffic—were either present or on call and committed to the project throughout the weekend. Two, the decisionmakers for those key areas and for the agency as a whole were also present or on call and equally committed. And three, the veteran core project development team was all in the same room and committed to the task. Without any of these key elements, the speedy decisionmaking necessary for such an endeavor would have [been] bogged down, [delaying] publication of the RFP"

Another example resulting from successful collaboration is WSDOT's work with environmental resource agencies. The Skagit is an environmentally sensitive river containing numerous threatened and endangered species. When the collapse occurred, WSDOT immediately notified local, State, and Federal environmental resource agencies, a standard practice in the State. By involving these stake-

holders from the start, the department could efficiently manage the environmental process in a timely manner.

Completing such a complex project in such a short time was an intense but rewarding experience. Decisions with long-lasting consequences had to be made quickly. To be able to make those decisions, detailed information had to be gathered rapidly, and that information had to be processed in a brief period of time, all the while ensuring that the project met the need and remained eligible for Emergency Relief funds. Collaboration and cooperation between the various WSDOT offices, the FHWA division and headquarters offices, and many other stakeholders and affected parties helped to write this success story for the replacement span of the Skagit River Bridge.

Jeffrey L. Horton, P.E., is an area engineer in the FHWA Washington Division Office. He received a bachelor's degree in civil engineering from Kansas State University.

For more information, contact Jeff Horton at 360-753-9411 or jeff.horton@dot.gov.

The author would like to thank Susan Wimberly, field operations team leader and Emergency Relief manager; and Debbie Lehmann, bridge engineer; both with the FHWA Washington Division Office, for their contributions to the article.

Communication, collaboration, innovation, and FHWA Emergency Relief funding were critical to replacing the collapsed span and upgrading the overhead elements to prevent further incidents. Here is the I-5 Skagit River Bridge with the new span and the main truss spans with modified portals and sway braces.



WSDOT

Along the Road

Along the Road is the place to look for information about current and upcoming activities, developments, trends, and items of general interest to the highway community. This information comes from U.S. Department of Transportation (USDOT) sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

Management and Administration

Secretary Foxx Breaks Ground on San Juan Improvements Project

Secretary of Transportation Anthony Foxx recently joined Puerto Rico Governor Alejandro García Padilla and other territorial officials for the groundbreaking of the PR-18/21 Improvements project on the island's busiest north-south corridor. The \$16.1 million project, which relies on \$14.5 million in Federal funds, is expected to improve traffic flow on one of Puerto Rico's key economic arteries and improve safety along a route with a history of crashes.

In addition to improved safety and overall traffic flow, the PR-18/21 project will improve access to and from the Centro Médico complex, a key medical facility that serves thousands of residents of Puerto Rico and nearby Caribbean islands. It will also provide better access for drivers and pedestrians alike to the Centro Médico Tren Urbano mass transit station, which serves the new Comprehensive Cancer Center site and the planned "Science City" east of PR-18.

According to the Puerto Rico Highways and Transit Authority, this project will help support thousands of jobs. Also, by reinforcing the growth of Centro Médico and Science City, the project will help inject \$560 million into Puerto Rico's economy.

When completed in 2016, the PR-18/21 project will support existing land uses and promote other modes of transportation, such as walking and cycling, and Tren Urbano ridership.

Deputy Secretary Mendez Celebrates Completion of Austin Expressway

U.S. Deputy Transportation Secretary Victor Mendez joined State and local officials at a ribbon-cutting ceremony to celebrate the completion of the Manor Expressway (U.S. 290 East) project to improve mobility in the Austin, TX, metropolitan area. The \$426 million project, which relied on \$122.5 million in Federal funds, has tripled capacity on a route that has seen traffic increase more than 78 percent since 1990. The project provides the Austin area with three new tolled expressway lanes in each direction, in addition to three existing nontolled arterial lanes in each direction.

The Manor Expressway project began in 2010 and spans 6.2 miles (10 kilometers) east of downtown Austin between U.S. 183 and SH-130. The first phase of the project included construction of direct connectors between U.S. 290 and U.S. 183, and 1.5 miles (2.4 kilometers) of a new toll road. The phase 1 projects opened to traffic in late 2012. Phase 2, which included



Central Texas Regional Mobility Authority

Deputy Transportation Secretary Victor Mendez (center) joined Mike Heiligenstein, executive director of the Central Texas Regional Mobility Authority, and Ray Wilkerson, chairman of the authority's board of directors, for the opening of the Manor Expressway in Austin, TX.

construction of U.S. 290 from Chimney Hill Boulevard to east of SH-130, opened to traffic in May 2014.

The project restores mobility to fast-growing eastern Travis County, making it safer for drivers to travel in the corridor. It also provides key connections to other important roadways in the region, including U.S. 183 and the SH-130 toll road.

In addition, the project included a 10-foot (3-meter)-wide shared-use path for bicyclists and pedestrians. The shared-use path runs for 6 miles (9.6 kilometers) along the Manor Expressway from the U.S. 183 interchange to east of SH-130. The path is separate from the road and connects with other trails in the area.

Technical News

FHWA Demonstrates Highway Friction Tester

The Federal Highway Administration (FHWA) is offering demonstrations of its Highway Friction Tester (HFT) to State departments of transportation. The HFT is a self-contained testing vehicle that maps friction at 1-foot (0.3-meter) intervals continuously along a pavement section. Agencies can use the friction data for both network-level and project-level applications, such as a pavement friction management program or a crash investigation.

Continuous testing improves an agency's ability to measure friction through intersections and around curves, and provides a more comprehensive picture of how friction varies in a section of pavement. The HFT uses a fixed-slip test method, which limits the slip of the test wheel to approximately 15 percent rather than fully locked, to deliver a coefficient of friction that is more representative of conditions experienced by vehicles with modern antilock braking systems.

FHWA's onsite demonstrations offer States an overview of the HFT's testing and data reporting capabilities, enabling agencies to conduct friction testing on their



FHWA's Highway Friction Tester, shown here, can assess pavement friction continuously through intersections and around curves.

local pavement surfaces. Demonstrations may range from a half day up to 5 days, depending on the testing location and the agency's goals for the demonstration. FHWA offers these demonstrations free of charge but may require participating agencies to provide traffic control.

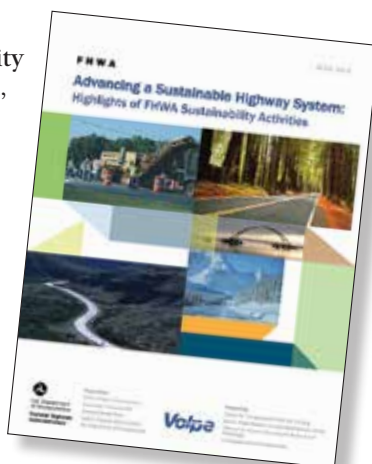
For more information, contact FHWA's Bob Orthmeyer at robert.orthmeyer@dot.gov or 708-283-3533, or David Merritt at The Transtec Group at dmerritt@thetranstecgroup.com or 512-451-6233. To schedule a demonstration, contact The Transtec Group at 512-451-6233, or request a demonstration online at www.thetranstecgroup.com/highway-friction-tester-demonstration.

Public Information and Information Exchange

FHWA Releases Report Highlighting Sustainability Activities

FHWA is committed to improving the sustainability triple bottom line—social, economic, and environmental outcomes—of its activities. To this end, FHWA has spearheaded a number of efforts to address and advance sustainability. These initiatives range from projects to mitigate climate change impacts to initiatives that promote sustainable pavements and improve safety, and to tools to better assess the benefits and costs of transportation investments.

In a recent report, *Advancing a Sustainable Highway System: Highlights of FHWA Sustainability*



Activities, FHWA describes how the agency has incorporated sustainability into a wide variety of its programs, projects, policies, processes, and partnerships. The report is intended for use by a diverse audience of transportation agency professionals at the Federal, State, and local levels, as well as by the public.

FHWA's goal is to encourage use of sustainable approaches in transportation planning, investments, operations, and other phases of project delivery. The aim is to help decisionmakers continue to enhance quality of life and serve the transportation needs of the present without compromising the ability of future generations to meet their needs.

For more information, visit www.sustainablehighways.dot.gov/FHWA_Sustainability_Activities_June2014.aspx.

NHTSA Launches TireWise Consumer Education Campaign

USDOT's National Highway Traffic Safety Administration (NHTSA) recently launched its TireWise campaign to provide consumers and retailers with essential information about choosing and caring for their vehicles' tires. NHTSA estimates that each year almost 200 fatalities occur as a result of tire-related crashes, along with approximately 11,000 total tire-related crashes.



NHTSA

NHTSA's TireWise campaign helps consumers appropriately choose and care for tires.

The TireWise campaign covers tire buying—how to select the right type, size, and rating of tire; tire pressure—how to check your tire pressure monthly; and treadwear—how to check tires for wear and other visual defects monthly. Other topics include tire aging—how tires break down over time; the effects of high temperatures—how to check tire pressure and conditions in hot climates; and replacing tires—how to learn when your tires were manufactured and follow the vehicle manufacturer's recommendation for replacement, regardless of actual miles on the tire.

To reach as many consumers as possible online and in stores, the TireWise campaign is featured on SaferCar.gov, and all of the content is also available to retailers and tire manufacturers across the United States.

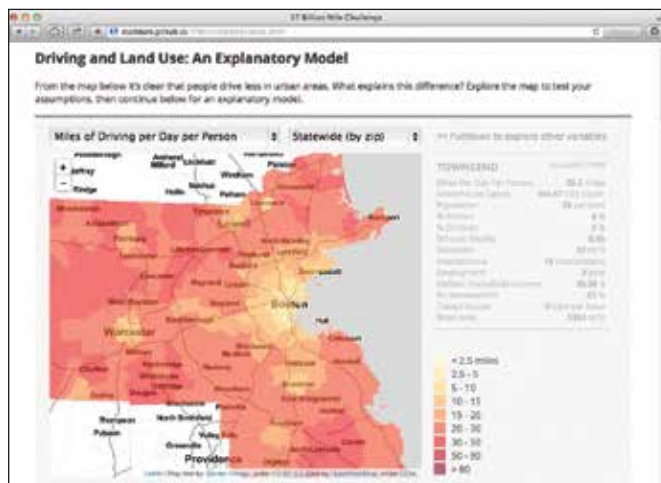
Users also can sign up for tire recall alerts for their specific tires and submit tire complaints from their mobile devices via NHTSA's SaferCar mobile app for Apple® and Android™ products. In addition, tire recall information is available by following NHTSA on Twitter and Facebook or by signing up on SaferCar.gov for the RSS feed and email alerts.

For more information, visit NHTSA's TireWise Web site at www.safercar.gov/tires.

NHTSA

Massachusetts Releases Vehicle-Use Data for Competition

The Metropolitan Area Planning Council (MAPC), the Massachusetts Department of Transportation (MassDOT), and the Massachusetts Technology Collaborative (MassTech) recently announced the results of their 37 Billion Mile Data Challenge. The competition challenged the data community to delve into a vast new set of anonymous vehicle-use data and produce innovative visualizations, applications, and insights on the Massachusetts transportation system. The results are intended to inform policy and help the Commonwealth build a more efficient and sustainable transportation system.



Paul Schimek, Zia Sobhani, and Kim Ducharme

The project "Driving and Land Use: An Explanatory Model" earned a best analysis award in Massachusetts's 37 Billion Miles Data Challenge. This interactive map shows miles of driving per day, per person by ZIP code. The project tested a variety of potential variables affecting driving patterns.

The winning entries ranged from "MasSEMIT," a tool that enables users to compare factors such as carbon dioxide emissions and fuel use by community, to a transportation infographic that informs the public on the true costs of driving. To view all of the entries, visit the event Web site at www.37billionmilechallenge.org.

The release of the new data set—the *Vehicle Census of Massachusetts*—represents a first-in-the-Nation release of State vehicle registry data. The vehicle census was created by MAPC, in partnership with MassDOT and with support from the Barr Foundation. The competition

also was made possible through support by MassDOT's and MassTech's work under Governor Deval Patrick's Massachusetts Big Data Initiative, a program launched in 2012, and other sponsors.

The challenge builds upon previous efforts to analyze and increase access to State transportation data, including the launch of the MassDOT "Developers Pages" online data resource, MAPC's Hubway Data Visualization Challenge, and the December 2013 "Visualizing Transportation" Hackathon run by MassDOT, MassTech, and hack/reduce (a Boston-based nonprofit). These efforts showcase the growing potential of open government data and collaboration to drive innovative public benefits.

For more information, visit www.37billionmilechallenge.org.

MassDOT

Caltrans Project to Ease Congestion, Create Gateway to Modesto

The California Department of Transportation (Caltrans) and the city of Modesto recently broke ground on a \$61 million interchange project to ease traffic congestion, improve operations, and increase safety on Pelandale Avenue at SR-99. The largest transportation project in Modesto history, the plans include creating a striking new gateway to showcase the city. Construction is expected to be completed in 2017.

The project includes doubling the number of lanes on the Pelandale overcrossing from three to six and building new ramps to connect SR-99 with Sisk Road and Salida Boulevard instead of busy Pelandale Avenue. Motorists will spend less time stuck in traffic burning up gasoline, which will save time and money and improve air quality. Additional auxiliary and merge lanes will be part of the interchange, giving motorists more time to safely merge and exit. The interchange also provides direct access to a nearby hospital. The improved traffic operations resulting



Caltrans

This simulated photograph shows what the SR-99/Pelandale Avenue interchange will look like when completed. The curved wall at right is engraved with the phrase "Welcome to Modesto: Water, Wealth, Contentment, Health."

from the project will enable emergency responders in the area to serve more efficiently.

Motorists entering the city from the north on the highway will view a sculptured and landscaped wall with a “Welcome to Modesto” greeting carved into the rock.

Project funding includes nearly \$44 million from Proposition 1B, a 2006 voter-approved transportation bond, and \$17 million from local and regional funds. Caltrans, the city of Modesto, the Stanislaus Council of Governments, and Stanislaus County worked together to secure funding for the project.

The existing interchange was built in 1970, and Modesto’s population has more than tripled from 62,000 to 200,000 in the last 45 years. An average of 110,000 vehicles travel along SR-99 at Pelandale Avenue daily, a figure that is projected to top 180,000 vehicles by 2035.

For more information, visit www.sr99pelandale.org.
Caltrans

“One Less Spark” Campaign Targets Wildfires Caused by Vehicles

The Arizona Department of Transportation recently announced its participation in the “One Less Spark, One Less Wildfire” public awareness campaign, an interagency initiative to raise drivers’ awareness of their role in preventing wildfires. The U.S. Forest Service and other land management agencies in California initially implemented the campaign in 2012. After success in California, the campaign is now expanding to other southwestern States.

“One Less Spark, One Less Wildfire” seeks to educate the traveling public in areas of high-frequency fires or areas that have the potential for catastrophic wildfire damage. The campaign provides information about the ways that vehicles can cause fires and the role the public plays in preventing them.



Vehicles can cause fires in several ways. Drivers should avoid parking in tall grass, because the heat from parts under the vehicle could start a fire. Anything that hangs underneath a vehicle and drags against asphalt, including chains used for towing, can cause sparks that lead to wildfires. In addition, exposed wheel rims can also cause sparks on asphalt; drivers should always check tire pressure before traveling.

The campaign features informational brochures and posters at rest area kiosks, bumper stickers, highway

signs, electronic billboard messaging to increase awareness in high-risk areas, and public service announcements that provide safety information and fire prevention tips.

For more information, visit www.preventwildfireca.org/OneLessSpark.

Arizona Department of Transportation

Now Available: Transportation Planning For Healthy Communities

FHWA and the Volpe National Transportation Systems Center recently released a white paper titled “Statewide Transportation Planning for Healthy Communities.” The second in a series of FHWA white papers on this topic, the document presents a flexible framework for State departments of transportation (DOTs) that choose to integrate public health considerations into their transportation planning and decisionmaking. The paper draws from five case studies of DOTs and their partners. (The previous white paper focused on metropolitan planning organizations and their transportation planning processes.)

The framework presented in the paper identifies key decision points—including motivations, early actions, and structural changes—for considering health both within the formal planning process itself and in related State programs. The analysis highlights common characteristics of DOTs that are including health considerations in their planning activities, such as support from leaders or legislators, active partnerships with other State agencies, and programs that facilitate the discussion of health and transportation (for example, Complete Streets and Safe Routes to School initiatives).

The project team concluded that there are several opportunities at various levels to support the consideration of health in transportation planning. In particular, metropolitan planning organizations and State DOTs may benefit from examining what each is doing and adapting techniques from each other’s approaches. USDOT and its Federal partners could provide further information by conducting research on health data and performance measures and by continuing collaboration with the Centers for Disease Control and Prevention to develop an analytical resource for DOTs to consider health in their decisionmaking.

The white paper is available at www.planning.dot.gov/documents/VolpeFHWA_DOT_Health.pdf.



by Kate Sullivan

Simplifying Project Delivery Decisions With GeoTech Tools

Problematic soil and rock conditions often negatively affect the construction costs, schedules, and long-term structure performance of transportation infrastructure projects. Geoconstruction techniques can help to address those issues with materials and methods to stabilize foundations, retaining walls, and other earthworks. These technologies also have significant potential to achieve some of the objectives of the Strategic Highway Research Program 2 (SHRP2), including rapid renewal of transportation facilities, minimal disruption of traffic, and production of long-lived facilities.

However, choosing the best geoconstruction technology for transportation systems is a complex endeavor that requires integrating available information with a number of factors specific to the task and the site. This complexity and the lack of a comprehensive system to assess information have resulted in geoconstruction technologies being underutilized by planners and engineers.

To address these issues, the Transportation Research Board's SHRP2 has developed a Web-based information and guidance system, *GeoTech Tools: Geoconstruction Information & Technology Selection Guidance for Geotechnical, Structural, & Pavement Engineers*. The system, available at www.GeoTechTools.org, helps engineering professionals assess critical information on geoconstruction techniques and assists them in deciding which technologies are applicable.

"The system is a comprehensive toolkit of geotechnical information that addresses all phases of decisionmaking to enable transportation projects to be built faster, to be less expensive, and to last longer," says Scott Anderson, a technical service team manager with the Federal Highway Administration's (FHWA) Resource Center.

Importance of User Involvement

Development of the system began in fall 2009. Eight reviews of the system during development, with input from potential users, led to revisions resulting in a more usable, intuitive system. The first release of the system was in November 2012.

Feedback and contributions from users were a primary objective in the design of the Web site. Even now users are strongly encouraged to submit technical updates or corrections, case histories, cost information, photographs, and references to expand and enhance the site.

A Multitude of User Options

GeoTech Tools enables users to select, design, estimate costs for, and monitor construction of nearly 50 geoconstruction technologies. The home page displays four columns representing components of the system: What's New, Catalog of Technologies, Technology Selection, and Contribute. On the left side of the page is a list with links to other features of the Web site, such as background on the SHRP2 project, geotechnical design process, a glossary, and other resources.

The two primary components of the system are the Catalog of Technologies and the Technology Selection System. The catalog page provides a listing of the technologies that are used for four elements of construction: new embankment and roadway construction over unstable soils, roadway and embankment widening, geotechnical pavement components, and working platforms.

When a user clicks on a specific technology, the Information Technology page appears. This page provides a description of the selected technology, plus links to supporting documents that users can access and download, including fact sheets, photographs, case histories, design guidance, quality control and assurance procedures, and more. Developers analyzed each technology to produce an indepth look at advantages and disadvantages, environmental conditions, and other information.

The other primary system component, the Technology Selection System, helps identify a short list of potential geoconstruction technologies for a user-defined set of project conditions. The Technology Selection page contains both a listing of the technologies sorted by classification and an interactive selection tool. In the classification system, the technologies are grouped into categories (such as Geotechnical Solutions for Earthwork Construction) that enable an experienced engineer to access solutions according to a specific category of problems. The Interactive Selection System uses a list of questions to determine potential geoconstruction technologies for a particular project.

As Matthew DeMarco, a SHRP2 engineer at FHWA, explains: "One of the best features of the GeoTech Tool system is that it was designed for a variety of users. Experienced engineers will benefit from the design, construction, and cost info provided in the Catalog of Technologies. Less experienced engineers and planners will also benefit by using the technology selection part of the system to assess the feasibility of various technologies in addressing project requirements and constraints."

For more information and to register, visit www.GeoTechTools.org.

Kate Sullivan is a contributing editor for PUBLIC ROADS.



by Imani Lester and Dr. Earl Lee

Bridge Inspection Course Goes to College

The Nation's bridge infrastructure relies heavily on the work of bridge safety inspectors to ensure quality, safety, and overall performance for public use. Therefore, safety inspectors are federally mandated to undergo comprehensive training to lead bridge inspection teams and become successful program managers. The National Highway Institute (NHI) developed Safety Inspection of In-Service Bridges (130055) and updated it in 2012 based on the latest edition of the Federal Highway Administration's (FHWA) *Bridge Inspector's Reference Manual* (FHWA NHI 12-049). The course provides the most current information on the safety inspection of in-service bridges.

To expose inspectors to a wider variety of bridge conditions and defects than they may easily find for training purposes in the field, NHI developed a virtual, computer-based 3-D alternative to the real-world field inspection required by the course. The 3-D Virtual Bridge Inspection includes two virtual bridges—a steel bridge over a roadway and a concrete bridge spanning water—that each present 15 checkpoints for student teams to investigate and evaluate. (For more on virtual bridge inspection, see "Training Update" in the May/June 2013 issue of PUBLIC ROADS.)

Now the safety inspection course is breaking new ground as the first NHI training to be used as a technical elective for an undergraduate college program.

Bringing Bridges into the Classroom

In January 2014 the Delaware Technology Transfer (T2)/Local Technical Assistance Program Center and the Department of Civil and Environmental Engineering at the University of Delaware hosted the bridge inspection course. Twenty-four junior and senior civil engineering students took the course during the winter semester to satisfy one of the three technical elective requirements for their degrees.

Professor Harry "Tripp" Shenton, chair of the department, had the idea to sponsor the course. "I thought it would be an excellent technical experience to put into practice what we are teaching in the classroom," he says. "I also knew that completing the course would be an advantage for this group of students when searching for jobs and internships."

The safety inspection course is one of only a few NHI structures courses that have a prerequisite requirement, which all of the students completed online without difficulty. Over the course of the 2-week training, students learned about a majority of current construction standards, bridge construction types, and even some materials not typically used today, but still in service. They also learned about other factors not associated with the structure itself, such as inspection safety, traffic control, signing, and approach railing.



Tom Ryan, Michael Baker Engineering, Inc.

These students in teams of two complete virtual inspections, using laptops in the classroom.

For the bridge inspection requirement of the course, the students used the computer-based 3-D alternative. They were able to inspect a bridge using virtual safety equipment, tools, and support equipment just like they would find in the field.

Measuring Its Success

The feedback from the student participants was very positive. "One of the best parts of the class was the interactive nature of it," explains Bobby Andersen, a senior civil engineering major at the University of Delaware. "The questions [the instructors] asked made the students think critically about what they just learned and apply it to the question."

When measuring the success of the course, Professor Shenton was pleased to report that all participants passed and received their certificates. It was also a success in that it provided a beneficial opportunity and experience for the students. The department intends to keep the course as part of its winter session offerings.

"I think it was a great opportunity for [the students] to learn the terminology and see actual photos of various bridge types or components before hitting the job market," says Diane Kretz, P.E., a structural engineer with the FHWA New Jersey Division, who also attended the course. "They all worked hard during their 2-week training, and I think their test scores probably would show it. I can't tell you enough what a great idea it was for the university to initiate this course for [its] students."

For more information, visit the NHI website at www.nhi.fhwa.dot.gov. For questions, contact NHI at nhicustomerservice@dot.gov or 877-558-6873.

Imani Lester is a contractor for NHI. **Dr. Earl Lee** is the T2 coordinator for the Delaware Center for Transportation.

Communication Product Updates

Compiled by Lisa Jackson of FHWA's Office of Corporate Research, Technology, and Innovation Management

Below are brief descriptions of communications products recently developed by the Federal Highway Administration's (FHWA) Office of Research, Development, and Technology. All of the reports are or will soon be available from the National Technical Information Service (NTIS). In some cases, limited copies of the communications products are available from FHWA's Research and Technology (R&T) Product Distribution Center (PDC).

When ordering from NTIS, include the NTIS publication number (PB number) and the publication title. You also may visit the NTIS Web site at www.ntis.gov to order publications online. Call NTIS for current prices. For customers outside the United States, Canada, and Mexico, the cost is usually double the listed price. Address requests to:

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State of the Practice and Art for Structural Health Monitoring of Bridge Substructures Publication Number: FHWA-HRT-09-040

Based on standards established by the Florida Department of Transportation and FHWA, visual inspections of U.S. bridges are required every 2 years. And although visual inspections are adequate, they do not provide a reliable way to determine the actual health of a bridge's foundation elements. This report offers an overview of the benefits of remote data acquisition systems for the short- and long-term monitoring of highway bridges. It also includes a discussion of previous methods for monitoring foundation health for compari-

son throughout the life cycle of the bridge.

Researchers used wireless communication and Internet systems technologies to provide remote monitoring capabilities for structural members. A voided shaft test site in Clearwater, FL, and a bridge replacement site in Minneapolis, MN, served as the primary proving grounds. Researchers obtained data from beneath the ground to assess health and performance, and to review capabilities of a low-cost automated data acquisition system. They evaluated the system by remotely uploading information to a host server and making spontaneous changes to the system configuration without a site visit.

The study provides an overview of procedures for remote automated monitoring that bridge owners can apply to a structural element to enable lifetime monitoring. These techniques include a variety of sensors and devices to record temperature, load, strain, movement, and other vital parameters to monitor structural health.

The study highlights the convenience and, in some instances, limitations and considerations when planning a remote monitoring program. It summarizes the successes and learning experiences gained from this project, including a review of the short- and long-term monitoring procedures implemented on the I-35W Bridge in Minneapolis, MN. Researchers explain the construction, setup, instrumentation, monitoring procedure, and results for a full-scale remote structural health monitoring system.

The report is available at www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/09040/index.cfm. Printed copies are available from the PDC.

An FHWA Special Study: Post-Tensioning Tendon Grout Chloride Thresholds Publication Number: FHWA-HRT-14-039

Elevated levels of chloride were recently found in a commercially pre-bagged grout powder for grouting tendons in post-tensioned bridges. The chloride value in the powders exceeded the current limits set by all of the domestic and international regulatory committees.

A chloride threshold is defined as the minimum chloride concentration needed to induce corrosion. However, there is limited information pertaining to the actual chloride threshold for seven-wire prestressed strands. Prompted by the high chloride levels found in the commercial powders, FHWA conducted a 6-month accelerated corrosion testing program to determine chloride thresholds for post-tensioned strands.



This report discusses the testing program and presents two chloride threshold values determined for post-tensioned strands that were fully encased in the contaminated grout. The first threshold value has a 0.4 percent chloride concentration by weight of cement, which is the lowest amount to initiate corrosion of the strands. At this threshold, researchers demonstrated that rust spots can form and a small number of pits can start to form beneath some of those spots. The second chloride threshold is 0.8 percent chloride concentration by weight of cement for corrosion propagation. At this threshold, researchers determined that corrosion starts to intensify in terms of the number of pits and pit depth; this threshold is considered critical.



Once a chloride concentration exceeds the critical threshold, significant corrosion damage can be anticipated, and the long-term structural integrity of the bridge may be compromised. If post-tensioned tendons contain carbonated grout, segregated grout, cracks in the duct, voids filled with water with or without chloride ions, or free sulfate ions in contact with the strands, corrosion is possible below the proposed threshold values.

This report is available at www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/14039/index.cfm. Printed copies are available from the PDC.

**Efficient and Safe Merging Solutions—
Advanced Freeway Merge Assistance: Harnessing
The Potential of Connected Vehicles
Publication Number: FHWA-HRT-14-045**

Freeway merging, a major safety concern, can cause traffic to slow and contribute to bottlenecks and crashes. This fact sheet discusses an Exploratory Advanced Research (EAR) Program project designed to improve the efficiency and safety of freeway merges using connected vehicle technology.

The project, Advanced Freeway Merge Assistance: Harnessing the Potential of Connected Vehicles, focused on developing and evaluating freeway merge assistance systems that may significantly improve operations in a connected vehicle environment.

As a starting point, the Center for Transportation Studies at the University of Virginia conducted a study in 2008 that developed strategic algorithms for improving merging. Researchers developed a dynamic lane control algorithm to encourage lateral movements of mainline vehicles by using a lower speed limit for the far right

lane of the freeway; a gap-responsive onramp signal algorithm to give a ramp vehicle the green light based on expected gap availability in the freeway mainline; and a merging control algorithm to control and advise speed changes for mainline and ramp vehicles to enable safe merging in the smallest space, at the highest speed possible.



Researchers on the EAR project aimed to enhance the efficiency and safety of these algorithms. Leveraging the communications capabilities of connected-vehicle technologies, the researchers integrated microscopic traffic simulations with wireless network simulations. The blended simulation results helped in designing and assessing traffic impacts of control actions associated with freeway merging. To determine the safety impacts of various scenarios, the researchers developed a safety evaluation module to project the number of crashes.

This research has the potential to significantly improve freeway merge operations. Additional research is recommended to further develop the concept of operations, understand its value, and identify promising deployment scenarios.

The document is available at www.fhwa.dot.gov/advancedresearch/pubs/14045/index.cfm. Printed copies are available from the PDC.

**Guidelines for the Implementation of
Reduced Lighting on Roadways
Publication Number: FHWA-HRT-14-050**

Streets and roads may be illuminated with more light than is necessary or lighting may be maintained too conservatively. The energy required for roadway lighting is considerable and can comprise a significant portion of a transportation agency's budget. The goal of adaptive lighting is to provide an acceptable degree of illumination for the safety of roadway users while minimizing costs.

The guidelines presented in this report address the need to maintain the safety effects of roadway lighting while alleviating the budgetary strains associated with the maintenance and operation of the lighting infrastructure. The report proposes a new set of criteria for practitioners to apply to their roadway environments. The criteria identify appropriate lighting levels for given roadway characteristics and usage.

The methodology for applying the criteria is based on existing international standards that accommodate various roadway characteristics and usage. The criteria presented in the report use real-world lighting data and robust statistical analysis of the crash histories of

associated roadways. Practitioners are likely to benefit from the enhanced data collection and statistical approaches.

For an adaptive lighting solution to produce a financial benefit, it should include a control system that is either central or localized on each luminaire, a dimmable-controls-ready luminaire, and a localized metering or negotiated adaptive lighting electricity rate. The control system, the primary component of the adaptive lighting methodology, should be monitored and managed from a central location.

Primary benefits of adaptive lighting include lower energy use (potentially a 20- to 40-percent reduction), reduced maintenance, fewer traffic interruptions caused by maintenance, less light pollution, and reduced roadway glare, all while maintaining roadway safety.

This document is available at www.fhwa.dot.gov/publications/research/safety/14050/index.cfm. Printed copies are available at the PDC.



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