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Insights on Oversight
Expanding e-Construction
ITS Then and Now

U.S. Department of Transportation

Federal Highway Administration

Public Roads

—featuring developments in Federal highway policies, programs, and research and technology—

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Front cover—With the roots of intelligent transportation systems reaching back more than 60 years, ITS technology today is transforming transportation by bringing connected and automated vehicles to everyday life. A survey of the evolution of ITS shows how the policies and key research came about. To learn more, see "ITS Is Changing the World," on page 18 in this issue of PUBLIC ROADS. *Photo: © TomasSereda, Thinkstock.*

Back cover—The Nation's highway system depends on a highly skilled workforce to build and maintain roads and bridges, like this one under construction. To overcome a potentially debilitating shortage of qualified workers, the Federal Highway Administration is working with the U.S. Department of Labor's Employment and Training Administration and other key partners to attract, educate, train, and retain a qualified highway construction workforce. For more information, see "Help Wanted" on page 36 in this issue of PUBLIC ROADS. *Photo: © Sergei Butorin, Shutterstock.*

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Guest Editorial

Making History Moving Transportation Forward

In 2016, the U.S. Department of Transportation celebrated three milestones: the 60th anniversary of the Federal-Aid Highway Act, the 50th anniversary of USDOT, and the 25th anniversary of the Intelligent Transportation Systems Joint Program Office (ITS JPO). During these time periods, the U.S. transportation system matured significantly. More recently, wireless connectivity has permanently altered the world around us—changing how Americans do business, keep up with current events, and connect with friends and family.

Connected vehicle technology is being deployed in U.S. vehicles and on the Nation's roads, and driverless cars are moving from the realm of science fiction into reality. On the cusp of these and other revolutionary changes to the U.S. transportation system, it is particularly apt to reflect on what USDOT can learn from the past to help shape the future.

Wireless communications have the potential to transform the U.S. transportation system. Research has shown that connected vehicles could save thousands of lives every year, while improving mobility, saving fuel, and reducing emissions. On the heels of extensive research, development, and testing, USDOT now is engaged in the exciting stage of real-world pilots and deployments—including sites in Wyoming, New York City, and Tampa, FL.

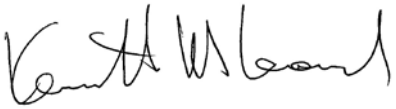
Furthermore, the Department's progress with connected vehicles can help advance other initiatives, including automated vehicles and smart communities. Automated vehicles can improve safety on U.S. roads, expand transportation capabilities, and extend mobility options to more people. Connectivity unleashes the full benefits of automated vehicles. The ITS JPO already is moving forward with research that advances connected vehicle concepts to automated vehicles. The technology USDOT and its partners have developed will give automated vehicles 360-degree awareness of the vehicles and infrastructure around them.

Connected and automated vehicle technology will play a prominent role in the move toward smart communities, which depend on connectivity and open data to ensure critical municipal systems work together and

operate efficiently to improve the lives of residents. Connected vehicles and infrastructure will yield unprecedented levels of data, which will be the basis for a multitude of innovative applications, leading to smarter vehicles, smarter infrastructure, and, ultimately, smart communities.

Over the past 26 years, USDOT's ITS portfolio has made great strides to improve the transportation system. To learn about the specific ways USDOT and the ITS JPO have invested in advancing innovative and life-saving technologies, see "ITS Is Changing the World" on page 18 in this issue of PUBLIC ROADS.

The connected vehicle and smart community programs are part of a much larger initiative to improve transportation by moving toward a more intelligent and connected system. By learning from and building on its rich history of transportation research, the ITS JPO can more fully explore and understand the possibilities of the future.



Kenneth M. Leonard
Director, ITS JPO
U.S. Department of Transportation

Notice: Effective October 1, 2017, PUBLIC ROADS will be transitioning from a bimonthly to a quarterly publication. The initial quarterly publication will be for the Autumn 2017 issue. Please direct any questions or comments regarding this transition to Editor-in-Chief Lisa Shuler at lisa.a.shuler@dot.gov.

by Thomas Harman

Ten Keys to Innovation Deployment

Cultivating organizations that embrace innovation can be challenging. That's why, in fall 2016, the Federal Highway Administration sponsored regional summits to launch the latest round of innovations in the Every Day Counts (EDC) program. The summits enabled leaders from the State Transportation Innovation Councils (STICs) to share strategies for building cultures that support innovation to meet the demands for a safe, efficient, and cost-effective highway system.

The national STIC network, which includes all 50 States, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and FHWA's Office of Federal Lands Highway, brings together stakeholders to identify and deploy innovations quickly. The seven EDC summits in 2016 featured townhall sessions at which STIC leaders discussed how they make innovation part of the everyday operations of their organizations. Their insights can be distilled into the following 10 keys to innovation deployment.

1. Users—like customers—are always right. Listen to those involved in deploying innovations and understand their needs.

2. Communicate the reasons why deploying an innovation is essential. Starting with the "why" helps pave the way to acceptance and support. "Encouraging people to ask why is a great thing, as is supporting them when they have a different idea," says Dallas Hammit, State engineer and deputy director for transportation at the Arizona Department of Transportation.

3. Expect resistance. Change is disruptive, but showing how an innovation can produce a significant improvement is crucial for buy-in. Says Chief Engineer Garrett Moore at the Virginia DOT: "In a limited-resource environment, innovation can be the difference between success and failure."

4. Foster innovation champions and encourage peer-to-peer communication. Peers who share similar experiences and challenges are likely to trust each other. "It takes a champion and success stories from other States to give the deployment team a degree of comfort that something is worth trying," says Mike Holder, chief engineer with the North Carolina DOT.

5. Strive for simplicity. Explain innovations in clear terms that audiences can understand easily. "You want to make your STIC relatable to your elected officials and the traveling public," says Jan Huzvar, deputy communications director with the Pennsylvania DOT.

6. Establish, build, and leverage an innovation network. As STICs mature, many expand their membership to a wider variety of public and private stakeholders, even creating regional networks. "Bringing interdisciplinary groups together makes innovation much more widespread," says Chief Engineer Rob McCleary at the Delaware DOT.

7. Reinforce the "how" and develop resources that address individual learning needs. It takes a variety of approaches and tools to train transportation practitioners in different age groups to deploy an innovation. In general, people retain more of what they see and hear than what they read. "When people are invested in a technology and empowered to think long term, we see a lot more success," says Laura Girard, a hydraulic engineer with FHWA's Office of Federal Lands Highway.

8. Tell a compelling story that conveys the impact of an innovation. Using data that quantify success can make the story more powerful, whether the result is shortening project delivery, improving safety, enhancing the environment, or reducing congestion or costs.

9. Manage change. Determine how to focus efforts to create a culture of innovation, and balance the addition of new technologies with the subtraction of outdated strategies or processes. "Look for ways to work to the strengths of the existing culture," says Ben Huot, a Utah DOT preconstruction engineer.

10. Celebrate and learn from mistakes. Leaders who support staff members even when an innovation proves unsuccessful create an environment in which people are willing to take risks. David Kuhn, New Jersey DOT assistant commissioner, says, "If you're not going to encourage risk-taking, you're not going to move that culture of innovation. It's okay to take risks."

To learn more about the STIC network, visit www.fhwa.dot.gov/innovation/stic.

Thomas Harman is director of FHWA's Center for Accelerating Innovation.

At Every Day Counts summits like this one in Baltimore, MD, transportation leaders discuss strategies for deploying innovations.

by Robert Ritter

Supporting Agencies at the Local Level

Nearly 39,000 local governments, tribes, and Federal land management agencies are responsible for maintaining the vast majority of the road mileage in the United States. That's about 3.5 million miles (5.6 million kilometers) of the total network of 4.2 million miles (6.7 million kilometers) and more than 300,000 bridges. These agencies face challenges that are similar to their State-level counterparts, such as rising construction costs and making their roads safer, as they seek to invest in needed infrastructure improvements.

"These agencies are looking for innovations and streamlined processes that will help them save lives, time, and money," says Victoria Peters, director of the Center for Local Aid Support.

That's where the Center for Local Aid Support can help. One of the centers in the Federal Highway Administration's Office of Innovative Program Delivery, the Center for Local Aid Support works to connect local, tribal, and Federal land management agencies to training, technical assistance, and information tailored to their needs. By advancing and promoting technologies and practices that other agencies are applying successfully, the center staff and its resources can provide a real benefit to these agencies as they manage their transportation programs.

Leveraging Transportation Resources

The Center for Local Aid Support focuses on helping agencies handle the challenges of maintaining, operating, and even expanding their transportation networks amid the increasing pressures of population growth, economic demands, and wear and tear on the existing system.

"Our center is about bringing technical assistance to locals," says Peters. "Our goal is to ensure that local, tribal, and Federal land management agencies have access to innovative technologies and practices that can save lives, time, and money for a resource-strapped industry, as well as capacity-building training for agencies that are expanding or losing experienced staff through retirement and attrition."

The center relies on the national network of Local Technical Assistance Program/Tribal Technical Assistance Program (LTAP/TTAP) Centers and FHWA's Office of Federal Lands Highway to deliver training and technical assistance. As champions of innovation, the Center for Local Aid Support staff members work with other organizations with connections to local transportation—such as the National Association of County Engineers, the American Public Works Association, and the American Association of State Highway and Transportation Officials—to identify areas where they can cooperate.

"We're looking at what services other organizations are delivering," says Peters. "There's such a significant need that one agency or group cannot cover it all. We have to leverage the resources that all of us are providing."

Learning from Peers

The center manages the Coordinated Technology Implementation Program, a cooperative technology deployment effort for Federal land management agencies that pilots proven technologies to solve transportation-related problems. Through technical briefs and webinars on the results of the pilot projects, the center shares knowledge with local agencies and tribes so they can apply proven approaches on their own projects.

"We want to showcase these ideas so individuals can build on the experiences of their peers and be a catalyst for agencies to try something new," says Peters. "Our experience shows that what works in one location will probably apply somewhere else in the United States."

Another example of innovation at work is the winning entries in the annual LTAP/TTAP Build a Better Mousetrap National Competition, which highlights solutions to everyday challenges encountered by local and tribal transportation workers. The winning entries include processes, tools, and equipment modifications—many developed by local staff in their shops—that enhance safety, efficiency, and quality and reduce cost.

The Center for Local Aid Support is a central location for information and innovative ideas and for leveraging the training and resources of other organizations. "It's a grassroots approach to innovation," Peters says. "We're transforming local aid support. We're here to help. Give us a call!"

For information on the Center for Local Aid Support, visit www.fhwa.dot.gov/innovativeprograms/centers/local_aid or contact Victoria Peters at 720-963-3522 or victoria.peters@dot.gov.

Robert Ritter, P.E., is the managing director of FHWA's Office of Innovative Program Delivery.

The Center for Local Aid Support provides resources to help local, tribal, and Federal land management agencies apply innovations on projects. Here, attendees of a showcase on geosynthetic reinforced soil–integrated bridge systems visit the construction site of the Sand Creek bridge replacement project in Crook County, WY, to see the innovation in use.

Out of necessity, FHWA took a different approach to fulfilling its roles and responsibilities on the complex New NY Bridge Project.

Transforming Stewardship and Oversight for Major Projects

(Above) In New York, FHWA used a risk-based approach to stewardship and oversight for construction of the New NY Bridge, shown here during main span construction of the project. *Photo: New York State Thruway Authority.*

by John Burns

Major infrastructure projects can be risky business. Major projects, those costing $500 million or more, typically have complexities such as a large scope, innovative financing, and alternative project delivery methods. These projects are very important to the Federal Highway Administration because of their national significance and the large amounts of Federal funding that make them possible. To protect the Federal investment and to ensure that Federal laws, regulations, and policies are followed, FHWA is charged with providing stewardship and oversight of these projects. Over time, FHWA has adapted how stewardship and oversight occurs to meet the challenges in carrying out its mission on major projects.

In the early days of building the interstate system, FHWA had full oversight on projects, meaning the agency was involved heavily and played central roles in the design and construction. However, as the interstate system was completed, additional laws changed the role of FHWA and delegated more responsibilities to States. The responsibilities and fundamentals of FHWA oversight still exist, but the way the agency performs its role continues to transform. The latest guidance, issued in 2014, furthered the transition from "full oversight" of projects to oversight activities

primarily focused on areas of higher risk and opportunity. FHWA's use of a risk-based approach for project stewardship and oversight intends to optimize the successful delivery of projects and to assure compliance with Federal requirements.

In the mid-1990s, the Central Artery/Tunnel Project (known as the "Big Dig") in Boston, MA, was moving along full throttle. FHWA dedicated a team of approximately 15 staff that provided the design and construction oversight. This level of oversight was unprecedented in the number of personnel and resources assigned to a complex project. Today, however, FHWA has fewer personnel and resources to dedicate to a growing number of complex projects. The entire FHWA workforce declined from approximately 5,000 employees in the interstate construction era to fewer than 2,900 employees today. In 2001, when the Big Dig was under construction, there were only 10 projects that met the FHWA threshold for a major project. Today, there are more than 100 FHWA major projects across the country that meet the criteria.

Gone are the days when FHWA can be involved to the level of its participation during the interstate era, or to have the same level of resources devoted to major projects such as the Big Dig. For today's major projects, FHWA needs a more creative and innovative way to get the job done. Therefore, FHWA is embracing project management fundamentals and conducting traditional stewardship and oversight in a risk management framework to successfully anticipate and manage uncertainties on major projects.

Taking a Risk-Based Approach in New York

Although the risk management framework is not new, the formal application of the risk model for the broad FHWA stewardship and oversight activities on major projects is a new approach.

Source: FHWA.

"Traditionally we have applied this framework to our division's performance planning process," says Joan Walters, program analyst with FHWA's New York Division, who assisted the division's project manager with the application of the risk management approach to New York's major projects. "But it can be applied to any of our programs, projects, or even for decisionmaking in our personal lives."

Today's major projects typically use alternative project delivery methods, such as design-build and public-private partnerships, which transfer responsibilities and risk from the traditional State sponsors to private companies. This approach compounds the complexity of projects and introduces uncertainties that could become deterrents to meeting FHWA objectives.

In New York, FHWA recently faced a major challenge in its stewardship and oversight duties on the New NY Bridge project. The New NY Bridge project is a $3.98 billion design-build project that replaces the existing Governor Malcolm Wilson Tappan Zee toll bridge with two new parallel cable-stayed bridges across the Hudson River from Rockland to Westchester counties. The owner and State sponsor is the New York State Thruway Authority (NYSTA). Completion of the project is scheduled for 2018.

Early in the project delivery process for the New NY Bridge, the staff at FHWA's New York Division Office knew that they needed a different oversight model. In the environmental and design-build procurement phases of the project in 2012, they identified numerous uncertainties—including the ability to meet FHWA requirements, commitments to project stakeholders, and unprecedented oversight requirements in the project's next phase, design and construction.

This bird's-eye view of the New NY Bridge from the Westchester approach shows the large scope of work for this major construction project. *Photo: NYSTA.*

To compound the challenge, the division had limited resources and only one staff member fully dedicated to the project: the project oversight manager. This project necessitated leveraging the strengths of other personnel in the New York Division and others within FHWA to provide additional assistance.

FHWA established a team for the project, including technical specialists from the New York Division, FHWA Resource Center, and FHWA headquarters office. The team, headed by the project oversight manager, first defined what stewardship and oversight would look like for the project. The team's approach included three elements: (1) stewardship—the "soft" activities that provided influence, leadership, and technical assistance; (2) oversight—the "hard" review and inspection activities that looked at compliance; and (3) approvals—the approvals FHWA would retain at key milestones or when Federal action was needed. The project team set this common stewardship and oversight vision to help define and prioritize their involvement in the project.

Establish the Project's Risk Context

The first step in FHWA's risk management model was to identify the project risk context. To accomplish this, the FHWA team working on the New NY Bridge had to establish the background and overall context, and define what FHWA success would mean for this project.

After the contract was awarded and entered the design-construction phase in 2013, the FHWA project team met and brainstormed what was specifically important to FHWA. This discussion was the first in a series that followed in the typical risk management framework.

The division project manager facilitated the initial discussion with support and leadership from Chris Gatchell, director of engineering at the New York Division. "With design-build being new to New York, the New York Division staff found ourselves not understanding our stewardship and oversight roles and responsibilities with respect to the project, which was creating confusion and frustration," says Gatchell. "This specific meeting focused on brainstorming ideas from the New York Division team about what they thought was important regarding the project. This required the team to think about FHWA's role. The result of this session really set the stage for the division office's project management plan and risk management approach for the project."

The team developed a set of goals, objectives, and specific Federal requirements for the project. They addressed how risks were allocated in the contract documents, how NYSTA was set up to provide the owner's oversight, and key commitments made to third parties, resource agencies, and the public. The team also reviewed and considered NYSTA's and the design-build contractor's preliminary risk registers that contained a list of potential project uncertainties including threats and opportunities. Furthermore, they evaluated and assessed the FHWA headquarters Resource Deployment Tool, which establishes a consistent risk context for comparing all major projects and for the deployment of resources.

The outcome of these activities was the following set of goals and objectives: to ensure that the project complies with laws, regulations, policies, and contract obligations; to provide leadership and technical assistance to the project sponsor; and to preserve the public trust in FHWA and the U.S. Department of Transportation.

FHWA also compared its goals to those of NYSTA and the design-build contractor. All had similarities and differences. Examples of similar goals included completing the project on time and maintaining a positive reputation. Some differing goals included the following: FHWA is primarily focused on meeting Federal requirements, while NYSTA is striving for low, long-term bridge maintenance costs, and the contractor has a goal to meet the project requirements while maintaining financial viability for its company stakeholders. This comparison provided insights on the way each entity approached the project, and it also pointed to potential areas of elevated stewardship and oversight risk where FHWA would need to spend more time.

The FHWA team's context for the project centered around the following key areas: (1) the project cost of $3.98 billion, (2) the use of innovative financing, (3) the 3.1-mile (5-kilometer)-long crossing with complex cable-stayed bridge, (4) challenging geotechnical conditions, (5) the project location in a suburban

The bridge is shown here at night during construction. *Photo: NYSTA.*

environment with sensitive human and natural resources and a number of environmental commitments, (6) the great deal of political interest in the project from Federal, State, and local levels, and (7) the use of design-build as a new project delivery method for the State. Identifying these key areas and a common vision enabled the team to advance to the next step in the FHWA risk management model: identifying the specific risks to achieving FHWA goals and objectives.

Identifying the Risks Of Many "Firsts"

The New NY Bridge was the first of its kind for the FHWA New York Division. It was the first large design-build project, the first cable-stayed bridge constructed by the State, and the first time the FHWA New York Division administered Transportation Infrastructure Finance and Innovation Act (TIFIA) financing. To top it off, the sponsor was nontraditional and did not have a long-standing relationship with FHWA. The FHWA team's knowledge of what could happen was limited, and a lot of uncertainty existed.

To help with this complex situation, FHWA used the Delphi technique. The technique is an established risk tool for soliciting opinions from a wide range of experts to gain a further understanding of possible project risks, including both threats and opportunities in various program or project delivery areas. This process enabled FHWA to cast a wide net and seek the unbiased opinions of project managers and technical experts within FHWA across the country. These experts had pertinent experience and helped to identify top potential risks and initial response strategies.

After the initial round of feedback in June 2013, the project team combined the responses and a consensus of top risks into similar risk categories and risk statements. The team entered these into a project risk register, which generated categories and areas that FHWA then converted into risk statements.

Analyzing the Risks

To analyze the identified risks, FHWA used a qualitative assessment to characterize the general likelihood and impact of the risks on FHWA goals and objectives. The team chose a qualitative approach over a more detailed quantitative approach because of the higher level oversight and stewardship role of FHWA.

Typically, FHWA project goals are broader compared to those of a State, contractor, or other project stakeholder. In this qualitative approach, FHWA assigned values to likelihoods (What is the likelihood of the risk event occurring?) and impacts (What is the impact of the risk on achieving project objectives?) ranging from high to low on a 5-point scale. This approach enabled a relatively quick assessment and a simple visual rating. To determine the likelihood and impact ratings, FHWA considered factors such as the level and experience of staff and the potential for waste, fraud, and abuse.

When FHWA conducted the risk scoring, it included the entire FHWA multidisciplinary project team rather than relying on only the subject matter experts to provide scores for the risk areas. Through this collaboration and crosscutting of program areas, all risk perspectives for the project were considered during the qualitative scoring process,

Risk Categories and Areas

- Environmental
  - Environmental - Process
  - Environmental - Permits
  - Environmental - Litigation
  - Environmental - Commitments
  - Environmental - Endangered Species
- Design
  - Design - General
  - Design - Geotechnical
  - Design - Major and Unusual Structures
  - Security
  - Right of Way
- Construction
  - Construction - General
  - Construction - Geotechnical
  - Quality Assurance Verification
  - Maintenance of Existing Traffic
  - Waste, Fraud, and Abuse
  - Buy America
- Civil Rights
  - Disadvantaged Business Enterprise
  - Civil Rights
- Funding
  - Funding - General
  - TIFIA
  - Tolling
- Project Management
  - Project Management Plan (Sponsor)
  - Oversight Staffing - FHWA
  - Oversight Staffing - Project Sponsor
  - Project Cost
  - Project Schedule
  - Political Influence
  - Technology Transfer

Likelihood Impact and Criteria

Likelihood Factors:
What is the likelihood of the risk event occurring?
- Staffing (Levels and Experience)
- Operational Procedures
- Guidance
- Problem History
- New Program, Phase, or Component
- Complexity
- Outside Control
- Potential for Waste, Fraud, and Abuse
- Workforce Development and Training
- FHWA Involvement
- Consultant Use
- Other

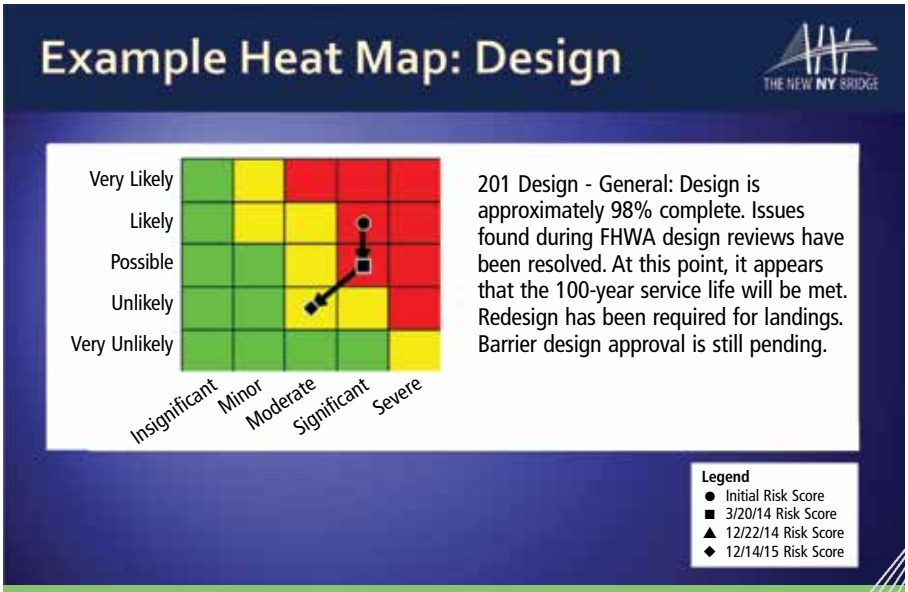
Likelihood Scores:

1 Very Unlikely
2 Unlikely
3 Possible
4 Likely
5 Very Likely

Impact Factors:
What is the impact of the risk on achieving project objectives?
- Ensure project complies with laws, regulations, policies, and contract obligations
- Ensure mobility and a safe, reliable, efficient, and secure crossing
- Provide timely reviews and subsequent approvals
- Preserve the public trust in USDOT/FHWA
- Technology transfer

Impact Scores:

1 Insignificant and Neutral
2 Minor
3 Moderate
4 Significant
5 Severe



This example of a heat map is illustrating design risk and trend. The red in the top right indicates the highest concern, while the green in the bottom left denotes the lower risk. *Source: FHWA New York Division.*

producing more unbiased and normalized results. The output of this step was a list of all the project risk statements ranked by priority.

Prioritizing the Risks

The team then reviewed and prioritized the assigned risk scores to determine where to focus FHWA resources. The team members generated a final risk score by multiplying the likelihood score by the impact score. These results were plotted on heat maps that visually show the likelihood versus impact. Risks plotted in a "red area" on the heat map are considered high risks, those in yellow are medium risks, and those in green are low risks.

The FHWA project team validated the prioritization by sending the risk statements, risk scores, and heat maps out to the larger FHWA team of experts. The whole team reviewed the work to make sure the ranked risks made sense, and to assess whether they needed to make adjustments or identify additional risks. The team modified a couple of the risk priorities after comparing the scores.

Response Strategies And Monitoring

For each identified risk, FHWA brainstormed a list of response strategies. What actions will FHWA take to mitigate, avoid, accept, or transfer threats, or enhance opportunities? The team included hard compliance activities (oversight), softer influencing and technical assistance activities (stewardship), and FHWA approvals required by law.

The FHWA project oversight manager, with input from the FHWA project team, assigned staff to take responsibility for each risk response. The outcome was a prioritized list of risk response strategies with FHWA staff assigned, and an overall understanding of the workload expected for FHWA staff.

In the final step (monitor, evaluate, and adjust), FHWA developed a stewardship and oversight plan based on the outputs from the risk framework steps. This plan includes all documentation of the process, including explanations of the risk identification, a summary of the latest risk scoring analysis with consideration of how risk scores are trending and mapping on heat maps, risk allocation, and tracking of risk response tasks.

FHWA shared the stewardship and oversight plan and risk register with NYSTA to assist with the alignment of risks and responses and so that NYSTA could incorporate the information into its risk management process.

The two key outputs for this stage were the plan and documentation of implemented strategies. FHWA updates the plan periodically and updates the risk scores on an annual basis.

Putting the Plan into Action

After FHWA identified the initial risks and developed its plan for stewardship and oversight, the division office involved the assigned personnel as necessary to put the risk-based approach into action. The following examples demonstrate how these individuals carried out their roles.

Geotechnical Stewardship And Oversight

Justice Maswoswe, a senior geotechnical engineer with the FHWA Resource Center, visited the New York Division Office upon request to discuss the project's geotechnical risks and potential response strategies. The soil and rock conditions for the project were challenging and presented a great risk. The bridge approaches have shallow water depths to extremely soft soils. The bedrock depth on the east approach and main span ranges from 200 to 300 feet (61 to 91 meters), and on the west approach bedrock depth is greater than 800 (244 meters).

These characteristics pose difficult choices for deep foundation types and introduce risks for foundation

This is a geotechnical soil and rock profile of the 3.1-mile (5-kilometer) New NY Bridge crossing. *Source: NYSTA.*

This Atlantic sturgeon, one of the endangered fish species identified through environmental compliance activities on the project, was captured as part of the sturgeon tagging study conducted pursuant to National Marine Fisheries Service Permit 16436. The effort was part of the net conservation benefit plan implemented by NYSTA. *Photo: NYSTA.*

capacity and constructability. Maswoswe reviewed the geotechnical soil, rock profiles, and other project information, and, together with the FHWA team, targeted certain areas for FHWA involvement during the design and construction of the project. Because they could not review all plans, they targeted the most important items that pose the greatest risk to the success of the project: a detailed review of the pile test program, a review of the geotechnical conceptual design report, a review of main span final designs, and construction inspections on each foundation type.

Risk in Environmental Commitments

Melissa Toni, the environmental specialist in the New York Division, was heavily involved in the National Environmental Protection Act (NEPA) process for the New NY Bridge project. She coordinated with resource agencies on permit requirements, and she led a consultation with the National Marine Fisheries Service to obtain a biological opinion for two endangered fish species.

The NEPA record of decision and biological opinion described the basis for the NEPA decision and summarized mitigation measures. The decision included environmental performance commitments and compensatory mitigation. Some of the risks included commitments during construction related to construction noise, air quality, water quality, and the two endangered fish species. FHWA, through Toni's involvement in the risk process, prioritized specific tasks including reviewing the environmental compliance plans and conducting environmental reviews in the field. Toni's involvement also included design reviews to ensure that designs and construction means and methods were within the environmental commitments and permits. This involvement enabled FHWA to advise NYSTA on when to consider designing to the permit condition, or when to apply for a permit modification.

Other tasks included coordinating with resource agencies at important intervals and reevaluating consultations proactively when required by project changes.

"Through the risk identification process, FHWA division office managers realized the amount of effort [required] to mitigate the key environmental risks for this project, and my workload was [adjusted] accordingly," says Toni.

Because of these specific risk responses by FHWA and work with NYSTA and the contractor, the environmental compliance is held to a high standard and FHWA is meeting its project goals.

Oversight of Cable-Stay Design

The cable-stay design presented a challenge for oversight because the FHWA New York Division, NYSTA, and the New York State Department of Transportation went into the project with limited experience with cable-stayed structures.

The New NY Bridge is the first of three cable-stayed bridges proposed in the New York metro area. This is the cantilevered span on one tower while under construction.

The main span towers and cantilevered sections of the New NY Bridge are shown here in the foreground and the existing Tappan Zee Bridge is visible in the background.

The design-build contractor had international experts with experience in other countries, but most with different design codes than used in the United States.

"The FHWA [New York] Division requested assistance from both FHWA headquarters and the Resource Center for technical cable-stayed structure design and construction support," says Dan Byer, a bridge engineer with the FHWA New York Division. "[We wanted] to capitalize on expertise and lessons learned nationally and internationally."

This was the first of three major cable-stayed bridges being constructed for the New York City metro area, all three being advanced by different owner agencies and design-build contractors. With FHWA being the common thread for these projects, the agency seized the opportunity to take a leadership role in some technical areas of the cable-stay bridge design and construction and share lessons learned with the various State partners.

Byer quickly broadened the FHWA team's knowledge and involved Brian Kozy, a structures engineer at FHWA headquarters, and Chris Millington, a structures engineer with the New York Division. Using the risk-based process, they identified the key risks: the edge-girder design, cable anchorages, redundancy, and security threats. Through targeted design reviews and meetings, FHWA worked with NYSTA and the project designer to review design plans and ensure that the bridge meets Federal regulations and policies. Furthermore, through indepth construction inspections, the FHWA team could provide a layer of quality assurance to verify that what was designed on paper was being built in the field and with acceptable quality.

Because this area presented a significant opportunity for technical assistance and technology transfer, FHWA delivered cable-stay design training for the contractor and State oversight teams and facilitated project visits at the other two cable-stayed bridge sites.

Material Quality and Acceptance

The design-build contract for the New NY Bridge assigned some of the traditional roles for quality assurance to the design-build company, while NYSTA maintained appropriate aspects of owner acceptance. In addition, NYSTA was poised to use new procedures for quality verification and owner acceptance for the first time in New York. This scenario presented high risks for FHWA in terms of material quality.

Tim LaCoss, a materials specialist with the FHWA New York Division for 20 years, stepped in to assist with targeting the high-risk areas in material quality. LaCoss championed the review of the design-build contractor's quality plan, helping to develop the quality verification software, and leading value-added construction inspections that concentrated on areas that posed the greatest threat to quality. For example, LaCoss helped the team target erecting the steel superstructure and fabricating the precast concrete deck panels. His actions led to recommendations and ultimately to solutions that improved the quality of materials used on the project.

FHWA targeted high-risk areas of materials quality, such as the erection of superstructure steel assemblies, shown here underway on the Rockland approach of the New NY Bridge. *Photo: NYSTA.*

These precast concrete deck panels for the New NY Bridge were fabricated and stored offsite. FHWA targeted these materials to ensure the quality of construction materials.

TIFIA Loan Financing

In December 2014, when the TIFIA loan closed for the New NY Bridge project at $1.6 billion, it was the largest TIFIA loan ever. It was also the first TIFIA loan to be administered by the FHWA New York Division. The loan agreement specified oversight activities for USDOT TIFIA loan officers and oversight activities for the FHWA New York Division. These activities were designed to protect USDOT interests and mitigate and monitor the risk.

This framework drove activities for Jim Griffin, division director of the Office of Finance and Administration with the New York Division. Griffin and the financial team, with the project oversight manager, held the responsibilities to mitigate risks and meet FHWA goals, including disbursing the TIFIA loan as planned.

The risk response activities included billing reviews for the first $1.6 billion to review eligibility for Federal funding and to ensure that progress payments had an acceptable cost basis. Other activities included certifying all billing requests, reviewing cost controls and procedures, and spot-checking earned value of progress payments. These activities aligned with the broader financial reviews that the USDOT TIFIA office conducted and in totality provided adequate protection of the Federal interests.

Disadvantaged Business Enterprise

From the beginning of the project, Christine Thorkildsen, a civil rights program manager with FHWA's New York Division, was involved in the risk framework for stewardship and oversight. She helped FHWA and NYSTA keep the focus on the administration of the Disadvantaged Business Enterprise (DBE) program, an important goal for FHWA and NYSTA because of the opportunities the goal creates for disadvantaged small businesses. The DBE goal for the project was set at 10 percent.

According to Thorkildsen, "Since the DBE program is a shared risk between FHWA and NYSTA, we focused on developing administrative DBE procedures that could be used within the confines of design-build contracting to meet the intent of the Federal regulation."

Specific risk response tasks to meet the DBE goal included the following: helping NYSTA establish the oversight team, reviewing the NYSTA oversight procedures, reviewing and approving the design-build contractor's DBE plan, and partnering with NYSTA and the design-build contractor to achieve DBE opportunities on this project. These efforts produced a greater understanding of FHWA expectations and a greater opportunity for success and compliance with Federal requirements.

Lessons Learned

FHWA learned a great deal using the risk management model to develop project-level stewardship and oversight roles on the New NY Bridge project. The model enabled the FHWA team to establish clear stewardship and oversight goals and to promote a common vision of success for the project. The model also assisted the oversight team to gain a greater understanding of the project and focus limited resources on the highest threats and opportunities. In addition, it facilitated the alignment of oversight activities with other partners.

"I can unequivocally say that FHWA's involvement in the New NY Bridge project has contributed greatly to its success," says Jamey Barbas, NYSTA project manager. "From the start, their oversight and guidance has been very collaborative and professional and targeted to areas that needed it most."

Risk-based stewardship and oversight accomplished using this approach aligns with the greater FHWA values of collaboration, serving the public interest, leveraging diverse thinking and experience, supporting all partners, and maintaining integrity in its decisionmaking. Because of the lessons learned on the New NY Bridge project, the Major Projects Team in FHWA headquarters has developed guidance on this approach for FHWA to use on other projects. This guidance is available to FHWA users on the Major Projects Microsoft® SharePoint® site.

John Burns is the FHWA specially designated project oversight manager for the New NY Bridge project. He has managed the project for FHWA through all phases, including the environmental process, design-build procurement, and, currently, the design and construction phase. Burns has been with FHWA for 20 years. He is a professional engineer and has a bachelor's degree in civil engineering from Rensselaer Polytechnic Institute.

For more information, contact John Burns at 518-431-8875 or john.burns@dot.gov.

NYSTA Project Manager Jamey Barbas and FHWA Project Oversight Manager John Burns stand atop the Main Span Towers of the New NY Bridge during an FHWA site visit. *Photo: NYSTA.*

State DOTs are transforming their approach to highway projects to keep pace with today's changing, mobile work environment. Check out these tips on how to go paperless.

(Right) The increased use of mobile technologies, such as smartphones and tablets, on jobsites is fueling the e-Construction revolution. Here, an inspector with the Texas Department of Transportation is taking a video of a stockpile of material with a smartphone. He sends the video via an app to a private company that analyzes the information and reports back on the quantity of the stockpile.

The Age of e-Construction

by Kathryn Weisner, Bryan Cawley, and Alicia Sindlinger

In the United States, many aspects of daily life—for purposes of both business and pleasure—involve cell phones, tablets, laptops, and other mobile devices. Today you can do just about anything online, from ordering lunch to applying for a mortgage. However, some aspects of highway construction and program implementation have resisted this evolution of "going electronic"—until recently.

Known for having lengthy delivery times, highway projects historically involve paper plan sets, paper documentation, and wet-ink signatures for contract documents and other approvals. Even with the introduction of computer-based management systems in recent decades, transportation agencies and contractors still print much of the documentation that is developed originally in electronic format simply because it is standard procedure.

Recently, the highway industry started revolutionizing how it does business to deliver projects more efficiently. The Federal Highway Administration and State departments of transportation are adopting e-Construction as a tool to reduce paperwork and associated costs, improve communication and environmental sustainability, and facilitate more efficient project delivery.

"We took a look at inefficiencies with the traditional paper-based system and quickly realized things can be done better and faster," says Tom Everett, associate administrator for the FHWA Office of Infrastructure.

Why It Works Better

e-Construction is a delivery process for construction management that includes electronic submission of all construction documentation by all

stakeholders, electronic document routing/approvals (e-signatures), and digital management of all construction documentation in a secure, paperless environment. The process enables distribution and access to all project stakeholders through mobile devices.

"It's doing all of this in a real-time environment," says Everett. "The contractor has portions of this electronic process that they interact with, the material suppliers also do, and the State does as well—all in a secure environment. So you know where all of the documents are, and you have reliability associated with them."

e-Construction employs many tools, technologies, and practices. Examples include mobile devices, software, and applications for field inspection and data collection; data hosting services such as data clouds, share sites, and virtual review rooms; and communications tools such as email, text, social media, Skype™ and FaceTime®, and other smart technologies. Practices include the transfer of electronic plans and electronic contract specifications and special provisions; electronic review and digital approval processes with transparency; real-time tracking using resources such as radio frequency identification (RFID) tags, quick response (QR) codes, and bar coding; and asset management including electronic as-built drawings and quality assurance.

e-Construction has piqued national interest because of its many benefits. State DOTs are realizing time and cost savings, enhanced quality, and improved data availability from e-Construction. States are mainstreaming many e-Construction system practices and showing significant returns on investment. Through enhanced awareness and promotion of benefits and examples of e-Construction application, the highway industry is ready to reap the benefits of program-level implementation.

Moving From Innovation to Practice

Recognizing the significant potential benefits to States, FHWA chose to include e-Construction in its third and fourth rounds of Every Day Counts (EDC). In EDC-3 (2015–2016), FHWA promoted this innovation and encouraged the use of readily available technologies—including digital and electronic signatures, electronic communication, secure file sharing, mobile devices, and Web-hosted data archival and retrieval systems. At the start of EDC-4 in February 2017 approximately 13 States have institutionalized e-Construction practices and the majority of other States were demonstrating, developing, and assessing.

With e-Construction, transportation agencies can reduce the need for storing large stockpiles of paperwork.

In the fourth round of EDC (2017–2018), FHWA is promoting e-Construction with a focus on how it enhances Construction Partnering among stakeholders, while improving communication and workflow to streamline the delivery of projects. These efforts are based on the belief that the full value of e-Construction is only realized by the use and implementation of effective Construction Partnering. Collaboration through e-Construction technology elevates the basic principles of Construction Partnering to a standard practice. (See https://partneringinstitute.org for more information on Construction Partnering.) FHWA's goal is to have 21 States institutionalize e-Construction and 13 States implement e-Construction and Construction Partnering by the end of 2018.

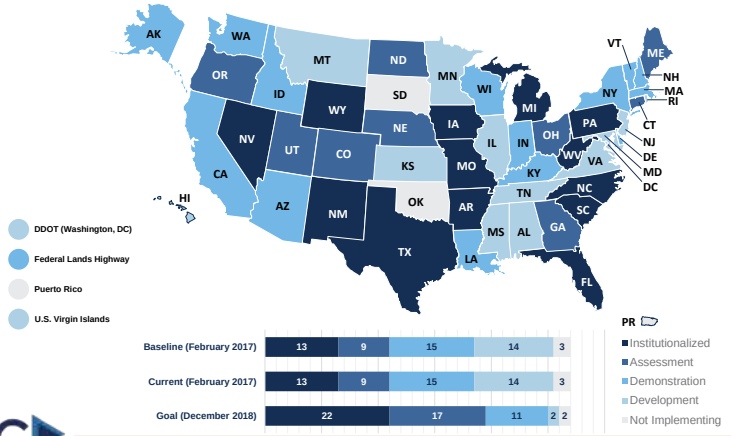
In addition to these efforts, FHWA led and completed a research project on e-Construction to collect detailed benefit and cost data. From this research, FHWA created a benefit-cost analysis template to capture cost data using the varying e-Construction tools over a 7-year timeframe. The template provides a framework for States to complete cost-benefit analyses, which

Benefits of e-Construction

Upon successful deployment of e-Construction solutions, agencies can expect to experience the following:

- Reduction or elimination of paper (sustainable solution)
- Operation in a secure environment
- Ease of document access and searchable text
- Real-time document access
- Controlled and improved document distribution and workflow
- Standardization of reports or forms
- Reduced storage and lost paperwork
- Enhanced disaster recovery
- Improved cash flow
- Reduction in claims
- Field staff on the jobsite for a higher percentage of time
- Easier access to manuals, plans, and project information
- Faster document approval
- Ability to sign electronic documents remotely
- Faster, more accurate payments to contractors
- Transparency—documents available for viewing by all project partners
- Integration with other core systems, such as accounting and asset management systems

e-Construction Implementation as of February 2017



Source: FHWA.

help agencies understand their starting point and then chart their paths on the e-Construction journey. To view the research report, visit www.fhwa.dot.gov/construction/econstruction/hif17028.pdf.

According to this research, the documented 7-year return on investment for construction management, project collaboration, mobile devices, and electronic bidding tools ranges from 200 to more than 700 percent. Time savings with e-Construction have averaged 1.78 hours per day per inspector, and inspectors have collected up to 2.75 times more data. In addition, DOTs have reported cost savings up to $40,000 per construction project per year.

FHWA Tests Mobile Devices

FHWA division offices work closely with their State DOT counterparts, which presents an opportunity to provide seamless project delivery and enable electronic integration, including electronic approvals by FHWA personnel. To assist with implementation of e-Construction, the FHWA Investment Review Board approved a pilot project in April 2015 to test tablet devices in several division offices.

The purpose of the pilot project was to evaluate the use of two types of mobile devices (Apple® iPad® and Microsoft® Surface® Pro tablets) and provide recommendations on the potential for agencywide implementation. Division offices in Florida, Iowa, Michigan, Texas, Utah, and West Virginia participated in the initial phase of the pilot. Each office tracked and reported performance measures (for example, reduction in paper use and reduction in processing and approval times) using predefined data sources.

The pilot agencies also reported information on the pros and cons of each device, the differences between shared and individually assigned devices, and the security and durability of the equipment in the field. In addition, pilot participants tested some mobile device applications for possible inclusion in USDOT's common operating environment.

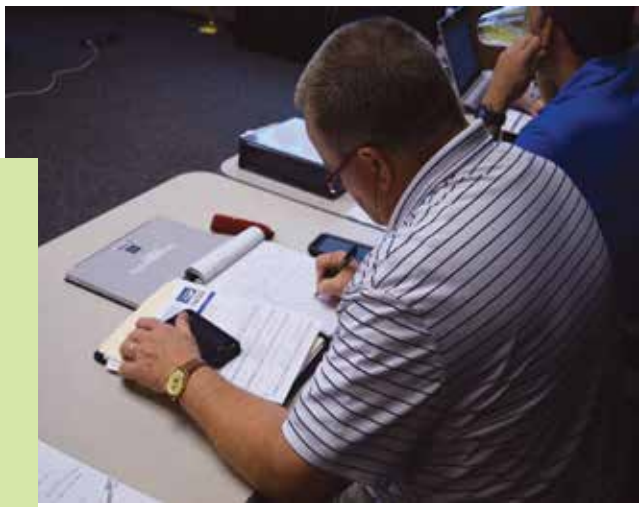
The enhanced mobility and real-time access to information proved effective for FHWA. Users reported benefits from both devices tested compared with traditional processes and activities performed without the tablets. The Texas division office, for example, deployed six devices for use by area engineers, which resulted in an estimated reduction of 47,815 pieces of paper and 655 hours saved between August 17, 2015, and January 18, 2016 (5-month period). In 2015, the Iowa division noted a reduction in printing needs for 51 plan sets through use of the iPad and also captured 100 photos on the devices for use in inspection documentation and reporting.

According to the Texas division office, the greatest benefit it realized during the pilot was the ability to do various tasks anywhere because of the mobility of a tablet. The Texas participants reported increased efficiency in general, but significantly in field inspections with photography for reports. Likewise, the Utah division reported benefits such as access to real-time information, a large reduction in paper resources, and time savings because of access to current information. Utah also noted the user-friendly benefits of tablets compared to laptop computers, including lighter weight, small size, and touchscreen capabilities.

On March 9, 2016, the FHWA Investment Review Board approved the expansion of the pilot to include other FHWA division offices in Missouri, North Carolina, Pennsylvania, and Virginia. The pilot was completed in March 2017, and agency implementation has been recommended through the annual computer refresh cycle.

Leading the Way: Michigan

Many State departments of transportation are working diligently to implement and refine e-Construction technologies and processes. The Michigan Department of Transportation (MDOT), for example, is one of the lead States. MDOT started using e-Construction on several pilot projects in 2012 and implemented full statewide paperless construction for all trunkline contracts starting with its October 2014 letting. Today, MDOT's trunkline construction operations are 99 percent paperless.



This participant at an EDC-3 peer exchange on e-Construction in November 2016 is taking handwritten notes, but also is monitoring two smartphones and a tablet (closed on the table in front of him). Today's transportation professionals can stay connected almost anywhere they go via their mobile devices.

Technology Used by Each Participating FHWA Division Office

FHWA Division Office	Device	Number of Devices	Activities
Florida	iPad Air (shared pool/platform)	6	Used routinely on project inspections and program reviews to load electronic inspection forms and for training for shared users.
Iowa	iPad Air (individually assigned)	7	Used routinely on field inspections and compliance assessment program reviews and to access Iowa DOT's document management system.
Michigan	iPad Air (individually assigned and 2 replaced computers)	7	Obtained access to MDOT sites outside FHWA's firewall through a policy exception.
Texas	Surface Pro (3 individually assigned and 3 in shared pool/platform)	6	Not using applications, rather using tablet as the main interface to capture information and data.
Utah	Surface Pro (individually assigned and 2 replaced computers)	4	Laptop replacement with Microsoft Surface Pro. Primary benefit cited as greater mobility as compared to laptop. Microsoft operating system enables uses similar to a laptop but with extra portability.
West Virginia	No devices assigned. Serves as the control for comparison to others.	0	Using laptops and working with the State Division of Highways to implement electronic signatures for change orders and other documents.

MDOT estimates cost savings of $12 million annually and savings of 6 million pieces of paper per year from e-Construction. It also estimates an average reduction in the processing time for complex change orders from 30 days to 3 days. The agency is seeing inspectors spend less time on paperwork, as well as increased employee and stakeholder engagement.

"This has really driven some enthusiasm from our employees," says Brad Wieferich, director of MDOT's Bureau of Development. "And they have really taken ownership in the process and have been the ones to help advance the ideas and make the process even more efficient."

MDOT is leading the way also by participating in peer exchanges. For example, in June 2016, MDOT hosted a peer exchange with the California Department of Transportation (Caltrans) in Lansing, MI. FHWA sponsored the event, the seventh in a series of peer exchanges designed to assist States with implementation while enabling peers to network and share information. In addition to staff from MDOT and Caltrans, the exchange included representatives from FHWA headquarters, the Resource Center, and each participating State's division office.

The peer exchange kicked off with discussion of the need for e-Construction technologies and associated training requirements, and maintenance of tools and technologies. The second day included demonstrations of software for project collaborations (such as SharePoint® and ProjectWise®), discussion of tools for labor compliance management (such as LCPtracker and AASHTOWare Project Civil Rights & Labor), materials management, and mobile devices. The day also featured contractor perspectives on e-Construction from the Michigan Infrastructure and Transportation Association, a statewide construction trade group.

On the final day of the event, participants discussed information technology security, enterprise-wide asset management, and e-ticketing concepts. The peer exchange concluded with discussion of key concepts for implementation and the future of e-Construction in Michigan and California.

PennDOT Goes Mobile

In 2015, the Pennsylvania Department of Transportation (PennDOT) adopted its first two mobile construction

Staff in the field can use tablet computers to take photos and add them to electronic reports, such as certifications and delivery documents, making the process much more efficient and accurate.

PennDOT

These PennDOT employees are using a mobile device to collect data at a construction site.

apps that the agency estimates will save more than $22 million in 2 years through improved efficiency. The apps further PennDOT's commitment to e-Construction by giving inspectors access to electronic forms while at project sites.

PennDOT has nearly 400 inspectors on staff and 1,200 under contract to check on the agency's roughly $2.5 billion worth of construction work underway each year. Prior to the app, inspectors had to consult paper documents and spend time traveling between their offices and construction sites to submit the reports. Now, inspectors use the software on their mobile devices to perform the same tasks directly from the field.

Through use of the mobile app, inspectors are in the field an additional 1.5 hours per day, or nearly 300,000 additional person hours each year. In the first year of use, PennDOT saw $11 million in productivity savings and estimates an additional $11 million in fiscal year 2017.

The National Association of State Chief Information Officers recognized the technology application as a 2015 finalist in the category of Improving State Operations.

PennDOT uses a Project Collaboration Center, a Web-based document management system, on all new construction projects to manage submittals and provide additional collaboration resources. During the construction phase of projects, the agency uses paperless submissions, except for material delivery tickets and material certifications. For the 2017 construction season, PennDOT is piloting electronic ticketing and working toward electronic material certification for the 2018 construction season. Construction staff throughout the State uses tablets to collect field data.

PennDOT's first mobile application enables field inspectors to access and download all documents and contracts to their devices, including specifications, drawings, and submittals. The second application enables the field inspector to complete a daily diary of the work performed by the contractor, including work item quantities ready for payment, and then synchronize that data to PennDOT's Engineering and Construction Management System for further workflow activities and document retention.

PennDOT has developed several additional mobile construction applications and is evaluating the cost savings from improved efficiencies.

Iowa Reaches Paperless Milestone

Over the past few years, the Iowa Department of Transportation has added pieces of the paperless process to its standard procedures. But in summer 2016, with the implementation of electronic bidding and contract execution, Iowa DOT reached a major milestone: 100 percent paperless on construction projects from the pre- to post-construction stages.

The Iowa Legislature paved the way for digitally signed contracts in 2004 by authorizing the process of signing legal documents online. However, because of the complexity of a construction contract, it was difficult to incorporate a digital signature. Adding to the complexity was the fact that the Iowa

Iowa DOT

The Iowa DOT has piloted e-ticketing technologies, which eliminate the need for inspectors to collect paper tickets from truck drivers who are delivering materials to construction sites. This process improvement increases safety and efficiency at the jobsite.

This inspector uses a mobile device to scan the barcode on a stockpiled pipe. After accessing the electronic delivery ticket for the material, she can link the e-ticket and the photos she shoots using the tablet to her daily report for measurement and payment.

DOT was forging the way, as no other State had created a process to incorporate digital signatures into the contracting process.

In addition to this breakthrough, Iowa has piloted electronic ticketing to track resources. Beginning in 2015 and continuing through 2016, the pilot projects tracked asphalt shipments online using GPS capabilities. In 2016, the agency also began tracking concrete loads delivered to the pilot location and collected data about them electronically. The electronic ticket data is then accessible to the State DOT for quality assurance of materials, source of supply, and payment.

For the 2016 portland cement concrete pilot, each driver had a tablet computer, and each concrete truck had a QR code. The driver would scan the QR code using the tablet, which connected the driver to that truck. Each time the truck was loaded, all relevant load data was automatically entered into the system and then passed to the tablet in the truck. With that information, inspectors could track the location of trucks through a mobile app in the field. It also provided the ability to access e-ticket numbers with the cubic yardage and certified material type. The traditional process required more time-intensive efforts with the inspector having to collect each paper ticket manually from the driver and then key it into a contractor pay spreadsheet.

With the pilots successfully completed, the agency's next step is to develop a standard specification. The agency also is working on a return-on-investment summary to quantify its expected savings from e-Construction.

Charting the Course To Full Deployment

FHWA will continue to support and promote the use of e-Construction across the country through ongoing efforts in EDC-4 and by facilitating additional peer exchanges between States.

In the next phase of deployment, many States will move from pilot projects to statewide institutionalization of e-Construction tools and technologies. States are also integrating components into single-interface, cohesive systems that move users from documents to data. Additional efforts moving forward include State DOTs expanding e-Construction to local agencies for local Federal-aid projects, extending access to contractors (several lead States currently do this, but not all) and consultant inspection staff, and archiving digital data for asset management and to meet Federal and State requirements for document retention.

EDC-4 efforts will focus on increasing awareness of how e-Construction tools and technologies facilitate increased partnering opportunities among all stakeholders—enhancing communication, transparency, coordination, and collaboration.

Within FHWA, the Investment Review Board will consider a pending recommendation from the pilot program for deployment of e-Construction mobile devices.

"There is no one way to deploy e-Construction, and there is no one technology to meet all your needs," says Everett. "But by starting with small steps and building strategically, States can revolutionize how they approach construction projects and reap the benefits of the efficiency and transparency of e-Construction."

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Bryan Cawley, P.E., is the division administrator for the FHWA Wyoming Division Office. Since joining FHWA in 1997, he has held a variety of positions in multiple FHWA offices. He earned an M.B.A. from the University of Nebraska, an M.S. in construction engineering from Iowa State University, and a B.S. in civil engineering from the University of Utah. He is a licensed professional engineer in North Dakota.

Alicia Sindlinger is the associate editor of PUBLIC ROADS.

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by Egan Smith

ITS Is Changing the World

Transportation is at a crossroads, and U.S. roads will never be the same again. As this technology advances, connected and automated vehicles will become a part of everyday life. Here's how it all came about.

(Above) Increasingly, transportation users and infrastructure are connected to one another wirelessly through technology. ITS is the backbone of this connected transportation infrastructure environment, which continues to evolve through the interplay of technology, industry, and government, and the ever-changing needs of transportation users. These technologies are being implemented globally to improve safety and reduce congestion and travel time. *Photo: USDOT.*

At this moment, the Nation stands at the cusp of some of the most revolutionary changes to its transportation system in decades. Connected and automated vehicles are closer than ever to being part of the everyday world of U.S. roadway users, and decisions made regarding these and other advanced technologies could affect the future of transportation profoundly.

With the United States moving toward an intelligent and connected transportation system, come along for a few minutes to reflect on the history of the field, recognize lessons learned, identify trends and their historical implications, and acknowledge both the successes and the missteps that have led to this point in the evolution of intelligent transportation systems (ITS). These systems advance transportation safety and mobility and enhance U.S. productivity by integrating advanced communications technologies into transportation infrastructure and vehicles. For a fuller discussion, see the *History of Intelligent Transportation Systems*, which this article summarizes. The publication was produced by the U.S. Department of Transportation's Intelligent Transportation Systems Joint Program Office.

Shown is an aerial photograph of the I–25 cloverleaf interchange to Speer Boulevard, a principal artery to downtown Denver, CO, in 1958.

The benefits of ITS technologies are wide ranging and apply to both urban and rural populations; commuters as well as commercial truck drivers; and pedestrians, bicyclists, and users of public transportation. Building on decades of ITS research and deployments, the very near future will likely include vehicles that can talk to one another and to roadside infrastructure to avoid collisions, reduce congestion, and alleviate environmental impacts. In fact, ITS will enable automated vehicles to interact with the transportation system—a concept that has captured the human imagination for decades and is closer than ever to widespread deployment.

Already, ITS technology has had a significant effect on the current transportation environment. In fact, the Nation is now on the verge of even greater benefits and impacts due to advances in this technology. For example, research on connected vehicles indicates that vehicle-to-vehicle (V2V) safety systems may cut up to 80 percent of those collisions that involve no driver impairment.

In addition, ITS technology is a key component of the movement toward connected and smart communities. Smart communities incorporate connected transportation to ensure that data, technologies, and applications—as well as connected travelers—are fully integrated with other systems across a community.

"As research, development, and deployment progress," says Ken Leonard, director of the USDOT's Intelligent Transportation Systems Joint Program Office, "these advanced solutions will increasingly yield even more benefits—beyond safety, mobility, and an improved environment—to include overall livability."

Roots in the Early History

In 1956, Congress passed the Federal-Aid Highway Act, which led to the creation of the U.S. interstate network. The 41,000-mile (66,000-kilometer) system was planned to reach every metropolitan area with a population larger than 100,000.

Over the ensuing decades, as speed on the interstates and congestion on urban interstates increased, so did the prevalence and severity of collisions. Safety had been a recognized automotive issue since the mid-1920s; however, government agencies did not begin setting vehicle and highway safety standards until the 1960s. Seatbelts, padded dashboards, standard bumper heights, and dual braking systems became mandatory for new cars in 1967.

The year before, on October 15, 1966, an act of Congress established the USDOT. Prior to this legislation, the Under Secretary of Commerce for Transportation administered many of the functions that are now associated with USDOT. Then the Highway Safety Act of 1970 established the National Highway Traffic Safety Administration.

During this early period, the roots of ITS can be seen in research initiatives and deployments undertaken by States and regions, academic institutions, and the automotive industry. Safety, decreased congestion, and improved mobility were the key driving forces.

Historically, the public sector has focused mostly on safety and environmental benefits. Private sector research and development, particularly during the early years, concentrated more on convenience and mobility. While coming at these various issues and technologies from different places, over time the two sectors have often converged in their approaches, resulting in joint projects and investments that have provided a variety of benefits.

Key Research and Technology Developments

In the 1960s, the public sector developed traffic management centers and ramp management techniques, and deployed dynamic message signs. Private manufacturers, such as General Motors through its Driver Aided Information and Routing System, conducted research on navigation and mapping techniques for motor vehicles. These efforts were followed closely, in the late 1960s, by the Electronic Route Guidance System developed by the Bureau of Public Roads (FHWA's predecessor), which provided navigation by transmitting radio communications between vehicles and roadside units.

Early mobile robotics research also began in the late 1960s, when

Integrated traffic management centers, such as the one shown here, are the center of most modern freeway management systems.

Seattle DOT

the Defense Advanced Research Projects Agency funded a project at the Stanford Research Institute to create the first mobile robot with the ability to perceive and reason about its own actions. At the time, the project was considered a failure for never reaching autonomous operation; nevertheless, the work established functional and performance baselines for mobile robots. Today, the navigation, sensory, and exploration functions used by mobile robots have been transferred to connected and automated vehicles.

The 1970s were a period of refinement of the research done in the 1960s, including development of map-matching algorithms that supplemented existing technology in early navigation systems and a modest USDOT-funded research program on automated vehicle highway systems.

The 1980s

Socioeconomic Environment. Gas shortages in the 1970s led to a congressional mandate that required new vehicles to achieve a minimum number of miles per gallon in fuel efficiency. In addition, widespread concern about air pollution and the environment led Congress to start regulating automobile emissions. During the 1980s, environmental concerns became the increasing focus of transportation policy. Safety was the other major focus as 51,091 fatalities occurred on the Nation's highways at the beginning of the decade.

In 1981, the first commercial car navigation system, the Honda Electro Gyrocator (illustrated here), was made available. *Photo: USDOT.*

In the midst of safety and environmental concerns, technology became cheaper and smarter—and technologies supporting improved traffic management emerged. Government agencies saw new possibilities for these emerging technologies to solve the environmental and safety problems associated with transportation.

At the same time, the transportation industry recognized new highway infrastructure-based technologies as a competitive business opportunity that could add value to their products. New technological developments with direct transportation implications were emerging—microprocessors, computers, sensors, and new communications technologies.

This decade coined the phrase intelligent vehicle highway system (IVHS), which described a group of technologies (including information processing, communications, control, and electronics) that connect vehicles to infrastructure to improve the safety and efficiency of transportation systems. During this decade, no formal national IVHS program emerged. However, much of the work in the 1980s set the stage for the current and future state and evolution of ITS, and facilitated the development and implementation of advanced technologies across transportation areas in subsequent decades.

Policy and Programs. During the 1980s, USDOT funded a modest program of university and in-house research on automated vehicle highway systems. The Department's

Key Milestones in the History of Intelligent Transportation Systems

1956 | Congress passes the Federal-Aid Highway Act (Eisenhower Highway Bill) and the U.S. interstate network is created.

1960s | The first dynamic message signs are deployed.

1966 | The U.S. Department of Transportation (USDOT) is established.

Late 1960s | The first North American traffic management centers are deployed.

1967 | Government agencies begin setting vehicle and highway safety standards; seatbelts, padded dashboards, standard bumper heights, and dual braking systems become mandatory for new cars in 1967.

1970 | The National Highway Traffic Safety Administration (NHTSA) is established by the Highway Safety Act.

1985 | The Defense Advanced Research Projects Agency (DARPA) Autonomous Land Vehicle demonstrations begin.

1987 | U.S. Congress establishes the University Transportation Centers through the Surface Transportation and Uniform Relocation Assistance Act.

1989 | Weigh-in-motion technology is deployed for commercial vehicle operations.

Pre-1980

1980s

Traffic Systems Division collaborated with several universities to conduct small-scale exploratory projects in freeway management, advanced traffic control, computer simulation, and driver information systems.

In parts of the country, pioneer applications emerged in arterial traffic control, information sharing on traffic conditions, and electronic tolling. In 1989, an advocacy group called Mobility 2000 formed to represent the new technology perspective. Mobility 2000 was essential in mobilizing support for a national IVHS effort, determining a conceptual definition for IVHS, and promoting the formation of IVHS America (now called the Intelligent Transportation Society of America, or ITS America), a Utilized Federal Advisory Committee to USDOT.

Key Research and Technology Developments. In the 1980s, the public sector developed and deployed weigh-in-motion technology. This technology enables quick identification and weighing of commercial vehicles while they are moving rather than stopped at weighing stations. Today, weigh-in-motion systems are widely used throughout the United States, saving commercial truck companies time and money, while also allowing inspectors to focus their efforts on high-risk carriers.

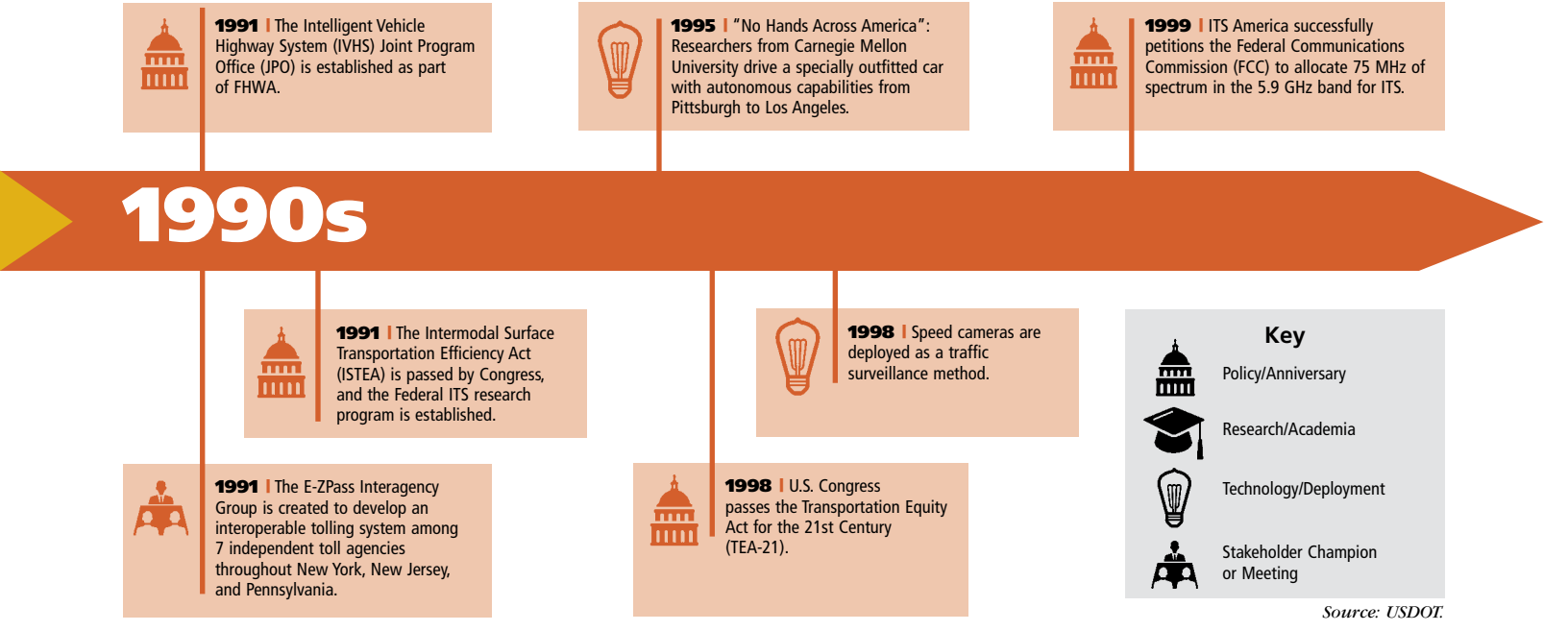
The 1990s

Socioeconomic Environment. In 1990, rapidly improving sensing and computing technologies suggested new possibilities for a safer and more efficient transportation system. Dialogue among committed transportation champions and stakeholders brought the concept of IVHS into the mainstream of transportation policy discussions. In 1991, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) was signed into law, reauthorizing the Federal-Aid Highway Program. ISTEA made a significant public commitment to institutionalize IVHS, establishing the foundation for the Federal-aid ITS program and the public-private partnerships that have continued to this day.

Policy and Programs. ISTEA established policies that recognized the shift in focus from the building of a surface transportation system to the operational management and maintenance of that system. With this shift, ISTEA encouraged the development and application of ITS technologies.

Also in 1991, USDOT established the IVHS Joint Program Office (JPO) to coordinate intermodal policy in the implementation of the IVHS program. With policy direction from the Office of the Secretary and modal administrators, USDOT located the IVHS JPO

This graphic shows a truck moving through a screening site with an electronic license plate reader and automated vehicle identification technology. The Heavy Vehicle Electronic License Plate (HELP) program has been developing a similar system that inspectors can use to screen trucks as they pull into weigh stations. *Photo: USDOT.*



Source: USDOT.

within FHWA. In fall 1994, USDOT renamed the national IVHS program as the ITS Joint Program Office to clarify the multimodal intent.

During the 1990s, one key activity of the ITS JPO was to establish a standards program to encourage the widespread use of ITS technologies in the Nation's surface transportation systems. These standards define how intelligent transportation components and systems interconnect and exchange information to deliver ITS services within a multimodal network. The consistent and widespread use of ITS standards will permit the sharing of data and information among public agencies and private organizations. Currently, nearly 100 standards have been published and are ready to use in ITS deployments.

The Transportation Equity Act for the 21st Century (TEA-21), passed in 1997, retained ISTEA's essential features while boosting investments in highway construction. TEA-21 transformed USDOT's ITS program from a moderate research program to one that both researches and deploys ITS technologies.

Today, ITS research and deployment focuses heavily on connected and automated vehicles. This focus is rooted in a range of activities that occurred in the mid-1990s:

- ISTEA mandated the development of an automated highway system to serve as the prototype for a fully automated IVHS in the future. USDOT carried out this ambitious program by sponsoring a competitive process to form the National Automated Highway System Consortium in late 1994. The consortium's work culminated in Demo '97, where more than 20 fully automated vehicles operated on I–15 in San Diego, CA. This project is an important ancestor of today's focus on automated and connected vehicles.
- Another key step toward making connected and automated vehicles a reality was a proposal by the Federal Communications Commission (FCC) to allocate 75 megahertz of spectrum for transportation services that improve highway safety and efficiency. The FCC allocated the 5.850- to 5.925-gigahertz band for a variety of dedicated short-range communications (DSRC) used as part of the national ITS program. DSRC systems provide a wireless link to transfer information between vehicles and roadside systems. The allocation of bandwidth for DSRC catalyzed the ITS JPO's focus on connected vehicle research. DSRC is essential in many present-day research initiatives with the goals of improving traveler safety, decreasing traffic congestion, and facilitating environmental benefits, such as the reduction of air pollution and increased fuel efficiency.

Key Research and Technology Developments. Electronic toll collection, a system that debits registered car owners' accounts electronically without requiring them to stop, was introduced in Europe in the late 1980s. The United States followed suit shortly after. In 1991, the Oklahoma Turnpike Authority's Pikepass became the first electronic toll collection system in the United States. Since then, electronic tolling has become widespread across the country, saving drivers time and decreasing congestion near toll plazas. The systems also can help decrease emissions and provide savings in equipment, annual operations, and maintenance costs.

The global positioning system (GPS), a network of satellites that beam down signals to GPS receivers, was developed originally during the Cold War for military and intelligence purposes. Only in the 1980s, however, was GPS released for use in civilian applications; then it became more readily available and affordable in the 1990s. Its more widespread availability and use opened up possibilities for data communications between equipped vehicles and transportation management centers, enabling

Key Milestones in the History of Intelligent Transportation Systems

2000s

2000 | The Federal Motor Carrier Safety Administration is established as a separate operating administration within USDOT.

2000 | FCC designates 511 as the single travel information telephone number across the country.

2004 | The Research and Innovative Technology Administration is established within the USDOT to support ITS initiatives.

2005 | The National 911 Program Office is established by NHTSA and the National Telecommunications and Information Administration.

2005 | The first high-occupancy toll lanes are deployed in Orange County, CA.

2005 | U.S. Congress passes the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

2006 | USDOT partners with CAMP to develop and test prototype vehicle-to-vehicle (V2V) safety applications.

2008 | USDOT conducted a proof-of-concept test to investigate the technical feasibility of V2V and V2I applications in Michigan and California test beds.

The E-ZPass lane shown here is an electronic toll collection system, which saves drivers time, reduces pollution, and costs less to operate and maintain than manual and coin tollbooths. *Photo: Fletcher6, Wikimedia Commons.*

a future of improved transportation management and efficiency.

Today, millions of users rely on GPS to navigate with great accuracy, whether on land, in the air, or at sea. Drivers can use in-vehicle portable navigation devices to determine the most efficient routes, find detours around traffic, and even receive traffic alerts or warnings regarding the locations of various safety cameras, such as fixed and red-light speed cameras. GPS is an essential element in the future of ITS because it offers increased efficiencies and safety on highways, streets, and mass transit systems.

Many new capabilities are possible because of GPS, such as carpools that enable riders to be matched instantly with a nearby vehicle.

The first speed cameras were introduced in the United States in Paradise Valley, AZ. Throughout the 1990s and early 2000s, increasing numbers of State and local jurisdictions adopted speed cameras. Their use is now widespread throughout many parts of the United States, and research consistently demonstrates that this technology has positive safety benefits.

The 2000s

Socioeconomic Environment. The first decade of the 21st century saw significant growth in communication technologies. Cellular technology spread, and the number and speed of Wi-Fi networks grew immensely. Cloud technology became more prevalent during this decade. The term "the cloud" first popped up in technology circles in the mid-1990s to describe a third-party system that houses digital information on remote servers.

2010s

2012 | U.S. Congress passes the Moving Ahead for Progress in the 21st Century Act (MAP-21).

2014 | Google unveils driverless car without pedals or a steering wheel.

2016 | USDOT announces Columbus, OH, as the winner of the Smart City Challenge.

2014 | USDOT issues Advanced Notice of Rulemaking for V2V communication technology for light vehicles.

2014 | ITS JPO releases the ITS Strategic Plan 2015–2019.

Key

- Policy/Anniversary
- Research/Academia
- Technology/Deployment
- Stakeholder Champion or Meeting

Source: USDOT.

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This man in a wheelchair is able to access a public bus thanks to the Mobility Services for All Americans initiative. Launched by ITS JPO, the initiative is a coordinated effort to apply technological solutions to barriers to accessibility and mobility for the transportation disadvantaged.

However, during the 2000s, cloud computing became more streamlined, widespread, and affordable, enabling the collection and analysis of significantly larger datasets.

Technological innovations that occurred during this decade have propelled ITS forward by assessing demand, automating and connecting technologies, and increasing opportunities for travelers along the entire trip chain to gather transportation information through social networking and smartphone applications.

Policy and Programs. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was signed into law in 2005. SAFETEA-LU affirmed the growing return on ITS investment and contained provisions to embed ITS into the mainstream of transportation planning and deployment processes, and to increase general awareness of improved operations brought about by the adoption of ITS applications.

In 2003, USDOT launched the Vehicle Infrastructure Integration project, whose mission was to use wireless communications between vehicles to achieve dramatic safety and mobility improvements. In 2006, USDOT collaborated with the Crash Avoidance Metrics Partnership (CAMP) to develop and test prototype V2V safety applications. Sound, robust data, such as that generated from CAMP's research, was required for NHTSA to make an informed decision on the future of V2V and vehicle-to-infrastructure (V2I) safety communications systems. The empirical data that this effort produced was critical to supporting NHTSA's decision to go forward with vehicle communications for safety.

An executive order established the Mobility Services for All Americans (MSAA) initiative in 2005. The aim was to improve transportation services and access to employment, healthcare, education, and other community activities through a coordinated effort enabled by various ITS technologies and applications. The MSAA initiative was built on several past and current USDOT-led activities to increase mobility and accessibility for the transportation disadvantaged and for the rest of the public, and to achieve more efficient use of Federal funding resources through technology integration and service coordination.

In 2008, the ITS World Congress in New York featured two test beds that demonstrated the integration of vehicle and infrastructure technologies. Applications included travel time information, intersection safety, transit signal priority, congestion pricing, electronic toll collection, and emergency vehicle preemption.

Key Research and Technology Developments. USDOT's Intelligent Vehicle Initiative, established in 1998, aimed to help reduce the number and severity of U.S. highway crashes through the development and commercialization of assistance products that warn drivers of dangerous situations, recommend actions, and even assume partial control of vehicles to avoid collisions. Also, USDOT established the Integrated Vehicle-Based Safety Systems (IVBSS) initiative to

develop and test integrated safety systems on both light vehicles and commercial trucks through partnerships with private vehicle industries. Under the IVBSS initiative, in 2005, USDOT entered into a cooperative research agreement with a private consortium to build and test integrated safety systems designed to prevent rear-end, lane change, and run-off-road crashes. This initiative directly led to the collision warning and driver assistance systems that appear today on a wide range of vehicles. These features include lane departure warning, blind spot monitoring, and collision avoidance systems. Beginning around 2007, manufacturers introduced the features on luxury cars and have now expanded to mainstream vehicles. In 2014, based on the promising results of this research, NHTSA mandated rearview video systems, also known as back-up cameras in all vehicles built starting in May 2018.

In 1999, USDOT petitioned the FCC to designate a nationwide three-digit telephone number for traveler information. On July 21, 2000, the FCC designated 511 as the single traffic information telephone number to be made available to States and local jurisdictions across the country. In the first 5 years after 511 was launched, more than 50 million 511 calls were made. The unexpected invention and growth of smartphones and traveler information apps eventually inhibited the relevance and long-term popularity of 511. However, the 511 coalition was categorically successful in encouraging States to establish collaborative working relationships with an eye toward technology deployment.

Although high-occupancy vehicle (HOV) lanes were introduced in the United States as early as the 1970s, the SAFETEA-LU law of 2005 mainstreamed the authority to create HOV lanes, with the primary purpose of increasing the total number of people moved through congested corridors. Since then, HOV lanes have become more widespread across the country. Today, there are nearly two dozen States that have some type of HOV, high-occupancy toll, or express lanes, many of which use some type of electronic toll collection for users.

The Present Day (After 2010)

Socioeconomic Environment. A variety of forces have shaped the present state of ITS technology. The economic downturn in the 2000s focused increased attention on making the most efficient use of the highway system and vehicle fleet. At the same time, communications and information technology evolved at a rapid rate. These factors ultimately led to innovative research initiatives and an explosion of new transportation apps.

Increasingly, ITS applications are considered in two contexts—for automated purposes or for connected vehicle purposes, or both. Automated vehicles are those in which at least some aspect of a safety-critical control function (for example, steering, throttle, or braking) occurs without direct driver input. Automated vehicles may be autonomous (that is, use only vehicle sensors) or may be connected. Connected vehicles use wireless technology to connect vehicle information and location to other vehicles (V2V), to infrastructure (V2I), or to other modes, such as internet clouds, pedestrians, and bicyclists (V2X). The wireless technology typically used for connected vehicles is DSRC, but some functions may use cellular or other types of communications.

FDOT

This roadside sign advertises the availability of 511 traveler information services.

Policy and Programs. In July 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law. MAP-21 funded surface transportation programs at more than $105 billion for fiscal years 2013 and 2014, and created a performance-based surface transportation program. In addition, MAP-21 continued support for ITS by restoring its research budget to $100 million per year and establishing the Technology and Innovation Deployment Program for $62.5 million per year. Finally, MAP-21 changed the focus of ITS activities by directing the Secretary of Transportation to encourage deployment of ITS technologies that will improve the performance of the national highway system.

The Fixing America's Surface Transportation (FAST) Act, signed into law in December 2015, continues the ITS program's emphasis on research, development, and operational testing of ITS aimed at solving congestion and safety problems, improving operating efficiencies in transit and commercial vehicles, and reducing the environmental impact of growing travel demand. Guided by the 5-year ITS strategic plan required by the FAST Act, the program currently focuses on significantly reducing crashes through advanced safety systems based on interoperable wireless communications among surface transportation vehicles of all types, traffic signals, other infrastructure systems, pedestrians, wireless devices, and automated vehicle systems.

The FAST Act contains many provisions to encourage innovation and accelerate the research and deployment of ITS technology, with an expanded role to enhance the national freight system and assist in developing cybersecurity standards.

In 2011, USDOT held the first public connected vehicle demonstration at the 18th ITS World Congress in Orlando, FL. This demonstration

USDOT

Automated vehicles will enable drivers to become passengers and engage in other activities while commuting, such as reading or catching up on work assignments.

was followed by the 2012–2013 Connected Vehicle Safety Pilot Model Deployment in Ann Arbor, MI. This real-world test of connected vehicle technology included more than 2,700 participating vehicles using wireless safety technology to help everyday drivers avoid crashes as they traveled along their normal routes. After analyzing data from the pilot program, NHTSA estimated that V2V technology could prevent more than half a million crashes and save more than 1,000 lives each year if implemented across the United States. This success prompted further USDOT actions and decisions. In December 2016, NHTSA released a notice of proposed rulemaking to enable V2V communications technology on all new light-duty vehicles.

Key Research and Technology Developments. Beginning around 2010, crowdsourcing commercial applications based on geolocation and cell phones, such as Waze and Uber, became available. These apps are influencing the ITS market and are part of a larger trend of shared mobility.

In recent years, both privately and publicly funded automated vehicle research and development have been moving swiftly forward. Private companies investing in automation technologies vary greatly in both their background and their approach to automation. In the race to automation, traditional automobile companies are joined by tech giants like Google and Apple and less traditional auto companies like Tesla.

Successful integration of these technologies depends on partnerships with multiple stakeholders, including these private companies, as well as research and academic institutions.

The Future

Technology has changed just about every aspect of Americans' day-to-day lives—including how they do business, keep up with current events, and connect with friends and family. Although billions of devices are now connected to wireless networks, the industry is still just scratching the surface of what is possible. In the future, widespread deployment of connected vehicles will increase traveler safety, while alleviating congestion issues. Partially and fully automated vehicles will become available to the public, further increasing mobility for road users. Furthermore, ITS technology applications, such as traveler information or traffic and demand management, will decrease burdens on roadways.

USDOT seeks to spur adoption of technology and help stakeholders and localities deploy maturing ITS systems. In 2015, USDOT awarded funding to the New York City Department of Transportation, Tampa Hillsborough Expressway Authority, and Wyoming/ICF for pilots of next-generation connected vehicle technology. The three sites have developed comprehensive deployment plans and are going through a design-build-test phase before running an operational environment. The pilots are expected to be operational by the end of 2018.

In 2016, Columbus, OH, won USDOT's Smart City Challenge, a national competition to implement bold, data-driven ideas that demonstrate the use of advanced data systems and ITS to make transportation safer, easier, and more reliable. As the winner of the challenge, Columbus will receive up to $40 million from USDOT to demonstrate innovative ways to connect cities and their cars and streets using advanced technologies. SmartColumbus is expected to be operational in 2019.

"The future of ITS will not be a one-size-fits-all solution," says USDOT's Leonard. "Transportation systems will need to be interoperable and yet allow local communities to tailor the service and applications capabilities they deploy to solve regional and local issues."

Egan Smith is the managing director of the ITS JPO. He has decades of professional experience in ITS and transportation management and planning. Smith is a registered professional engineer, professional traffic operations engineer, and professional transportation planner. He has a bachelor of science degree in civil engineering from the University of the West Indies, a master of engineering degree in traffic engineering and operations research from Howard University, and a master of science degree in technology management from the Polytechnic Institute of New York University.

For a more detailed report on ITS history, visit http//its.dot.gov/history or contact Mike Pina at 202–366–3700 or mike.pina@dot.gov.

JOURNEY THROUGH THE

HISTORY OF INTELLIGENT TRANSPORTATION SYSTEMS

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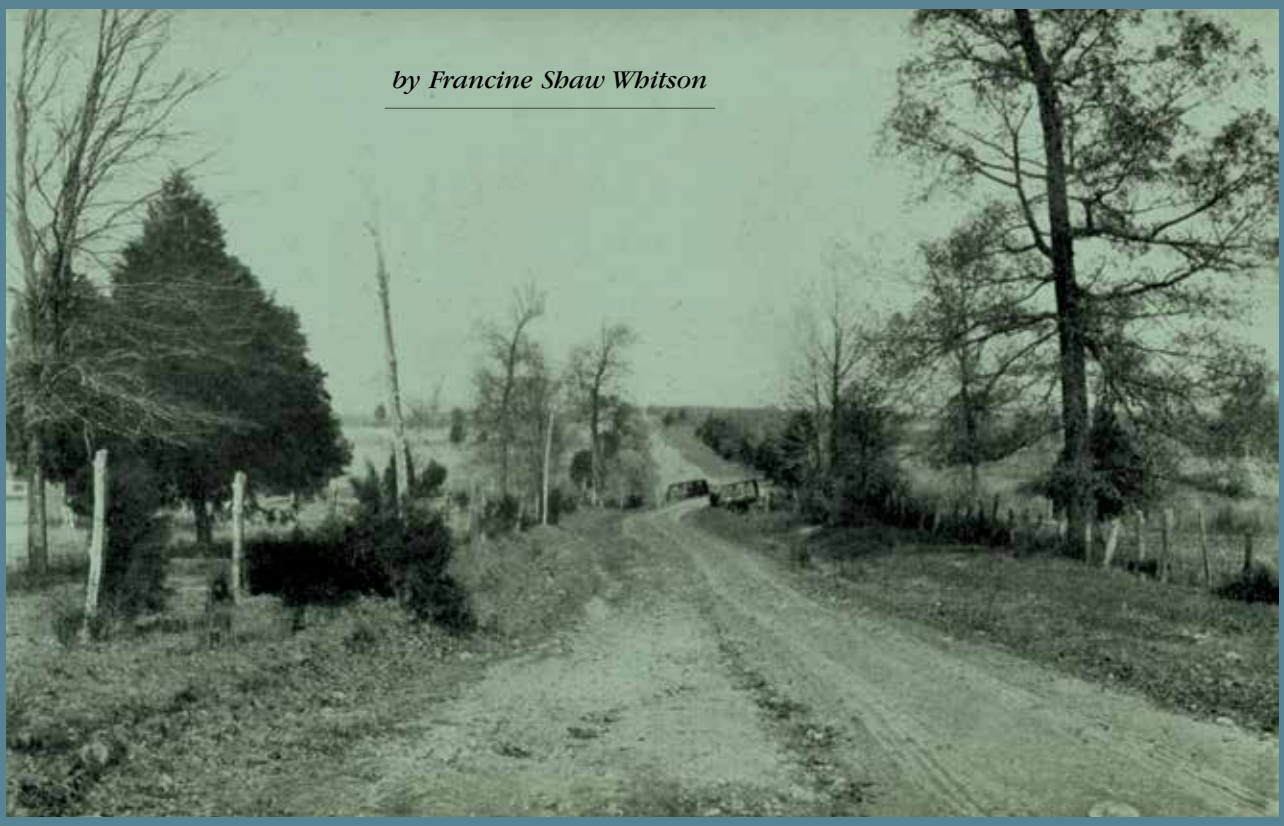
U.S. Department of Transportation

Dollar for Dollar

Transportation performance management could change how DOTs go about their business on a day-to-day basis. To find out what this new era is all about, read on.

by Francine Shaw Whitson



A dollar spent does not necessarily result in a dollar's value, as evidenced in this photograph from 1911 showing a bridge that is poorly located creating short, sharp curves.

On July 11, 1916, President Woodrow Wilson signed the law that created the Federal-aid highway program. During a review of regulations for the new program, Secretary of Agriculture David F. Houston, whose department would administer the funds through the U.S. Office of Public Roads and Rural Engineering, told State highway officials:

"The main question that I am immediately concerned with, that the people of the Union are immediately concerned with, is whether we shall get a dollar's result for every dollar we expend for roads. I am quite sure that if we do so and we can convince the people that we have done so, they will be willing to put much more money into good roads where they are needed."

During the century since then, the Federal road agency and the State transportation departments have tried to measure the results of their expenditures. They have tabulated the number of Federal-aid projects, the road mileage by type of surface, and the number of vehicle miles traveled, to cite just three variables.

In 1945, the Federal road agency launched *Highway Statistics*, an annual compendium of data on roads, financing, and vehicles. More recently, the Federal Highway Administration has worked with States to inspect all bridges on public roads. State and local officials use that data to set priorities for bridge replacement and rehabilitation.

In the 1980s the newly introduced concept of management systems enabled highway officials

to use the speed of computers to tabulate pavement and bridge management data that could be used to establish priorities for transportation spending. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) suggested additional management systems for highway safety, traffic congestion, public transportation facilities and equipment, and intermodal transportation facilities and systems. Little progress was made on those systems, however, because Congress, after concluding the systems had little support in the transportation community, canceled implementation.

In addition, every few years, FHWA works with the Federal Transit Administration to compile data for a Conditions and Performance report to Congress on the Nation's roads, bridges, and transit systems. In these and other ways, FHWA and State transportation officials gather data for use in decisionmaking and outreach to the public.

Despite all this information gathering, the question is how can officials best use the data to measure performance to provide better transportation service to the public?

The answer: transportation performance management (TPM).

The Measuring Stick

In the 1910s, the measuring stick was simple. It involved how best to improve unpaved country roads and bridges built for horses and wagons. That was a challenging proposition for the designers of those early days when many road officials were not engineers and often believed in the rule of thumb, guestimates, and the old reliable, "We've always done it that way."

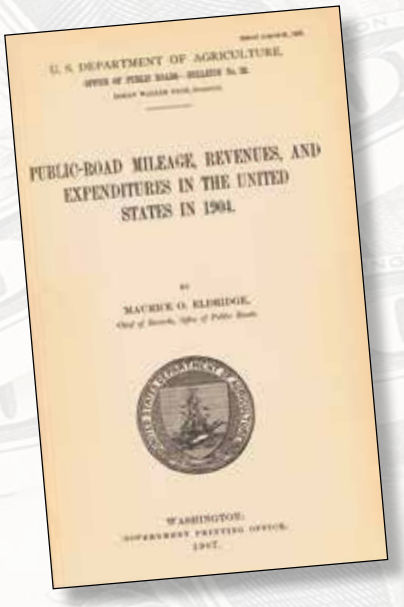
Thomas H. MacDonald, the engineer who headed the Federal road agency from 1919 to 1953, discussed the results, merits, and limitations of the Federal-aid highway program in his first speech as agency chief to the American Association of State Highway Officials. Any discussion of these topics, he said, "rests entirely upon a careful scrutiny and analysis of the uses which we are now making, and which we will make in the future, of our highways."

These uses could be classified as relating to the agricultural, recreational, commercial, and military sectors, ranked roughly in that order based on traffic volumes. Officials would be judged by how well they honored the "principle that the roads which we are building must serve these four classes of traffic."

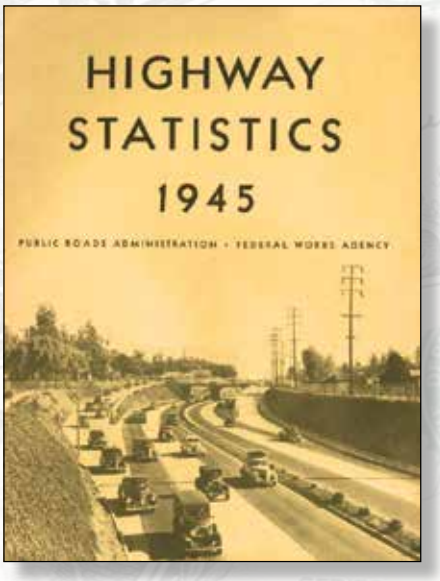
Meeting that principle, as it evolved across the decades, has been a challenge for each generation of transportation officials. Today's generation, as in the past, must build or improve roads and bridges to the best of their engineering expertise, but in doing so must consider economic, environmental, preservation, social, and other values that were not factors in that long-ago era. How, officials must ask, will a given project affect air quality, the ozone layer, noise levels, neighboring communities, the flow of development, and the use and value of adjacent properties?

As reflected in the development of pavement and bridge management

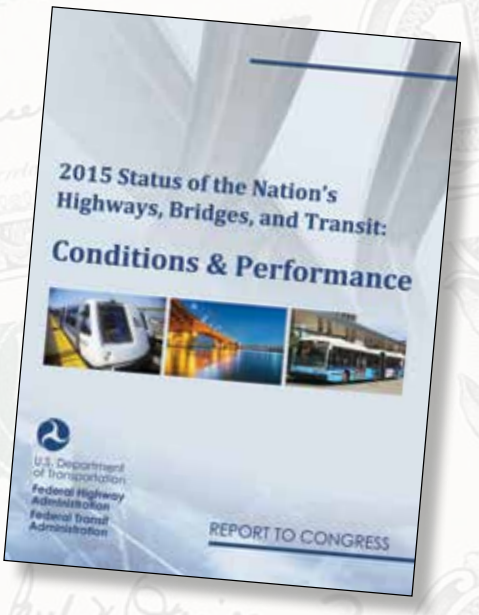
A Century of Highway Data Publications



In 1904, the Office of Public Roads conducted the Nation's first road inventory. The results, compiled in this 1907 bulletin, showed that the country had 2,151,570 miles (3.5 million kilometers) of rural public roads, only 7.14 percent of which had been improved.



In 1945, the Federal road agency began publishing *Highway Statistics*, an annual compilation of statistics on motor fuel consumption, motor vehicle registration, State highway user taxes, financing of State highways, and highway mileage.



Today, FHWA issues periodic reports on the condition and performance of the Nation's highway and transit systems. In addition to the current state of performance, the reports provide an appraisal of the future state under alternative investment scenarios.

This 1908 image shows an automobile raising a dust cloud, a common problem with earth, gravel, macadam, and other surfaces during the early automobile age, until research provided solutions.

systems in the 1980s, officials were searching for ways to pull wide-ranging data together, filter it through a computer, and set priorities for public investment. Officials were hesitant to give up the human role in decisions to an impersonal matrix of facts resulting in conclusions that exclude emotions, media scrutiny, politics, and other nonquantifiable factors.

In addition, transportation officials now have to take into account all modes of transportation—not only as alternatives to roads, but also as choices that fit into a multimodal network serving more than 320 million people who live and work in a global economy made possible in part by improved transportation.

Today, the transportation community is ready to begin a new era of measuring the transportation network so that its officials can manage it better.

Transportation Performance Management

The Moving Ahead for Progress in the 21st Century Act (MAP-21) of 2012, as amended by the Fixing America's Surface Transportation (FAST) Act of 2015, established a new approach for carrying out the Federal-aid highway program. The new method—transportation performance management—is a strategic approach that uses system information to guide investment and policy decisions to achieve national performance goals.

This new concept, MAP-21 declared, would "provide a means to the most efficient investment of Federal transportation funds by refocusing on national transportation goals, increasing the accountability and transparency of the Federal-aid highway program, and improving project decisionmaking through performance-based planning and programming."

The legislation directed the Secretary of Transportation to issue regulations to establish national performance measures and to require the State departments of transportation and metropolitan planning organizations (MPOs) to establish performance targets organized under 12 national measurement areas. The new regulations also were to articulate how FHWA will assess whether DOTs have met or made significant progress toward meeting their targets.

The Road to Regulations

The road to promulgating these regulations has not been easy. The complexity of the 12 measure areas and the lack of national data sources increased the challenges.

After careful consideration, FHWA broke the rulemaking into three separate sets of rules, ranging from those with less complexity—safety regulations—to the most complex: performance regulations for the National Highway System, freight movement, and the Congestion Mitigation and Air Quality Improvement Program.

On March 15, 2016, FHWA issued a final rule on the safety performance measures because DOTs and MPOs are already familiar with that area, given the measurement work by the National Highway Traffic Safety Administration. For information on the TPM safety regulations, see "What Drives Highway Safety Improvements," in the November/December 2016 issue of PUBLIC ROADS.

Infrastructure Performance

The second group of measures addressed by FHWA focuses on infrastructure performance and the condition of the National Highway System. These measures include the performance of pavements, both on interstate and noninterstate routes in the National Highway System, as well as bridge conditions on all the National

Performance Measure Areas

1. Fatalities per vehicle miles traveled
2. Serious injuries per vehicle miles traveled
3. Number of fatalities
4. Number of serious injuries
5. Condition of pavements on the interstate system
6. Condition of pavements on the National Highway System
7. Condition of bridges on the National Highway System
8. Measures to assess traffic congestion
9. Measures to assess onroad mobile source emissions
10. Measures to assess freight movement on interstates
11. Measures to assess the performance of the interstate system
12. Measures to assess the performance of the National Highway System excluding the interstate system

Highway System roads. In 1991, ISTEA required management systems for pavements and bridges, laying the groundwork for these infrastructure performance measures.

In proposing these measures, FHWA relied on two sources of data that have been collected for many years: the National Bridge Inventory (NBI) and the Highway Performance Monitoring System (HPMS).

The NBI is a database of information on more than 600,000 of the Nation's bridges on public roads, including interstates, U.S. numbered highways, and other State, county, and municipal roads, as well as publicly accessible bridges on Federal lands. The inventory presents a State-by-State summary and analysis of the number, location, and condition of highway bridges.

Congress authorized the collection of NBI data by statute (Title 23, United States Code, Section 151, National Bridge Inspection Program), which FHWA implemented by regulation (Title 23, Code of Federal Regulations, Part 650.301). With these authorities, FHWA established National Bridge Inspection Standards (NBIS) for the safety inspection and evaluation of highway bridges. Each facility owner is required to conduct periodic inspections of all bridges subject to the NBIS, prepare and maintain a current inventory of those structures, and report the data to FHWA using the procedures and format outlined in the *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*.

For the TPM rulemaking, FHWA naturally wanted to use the NBI database because it already contains the information needed on the condition of bridges, with a mechanism for regular updates.

The HPMS is a national highway information system that includes data that the DOTs submit on the extent, condition, performance, use, and operating characteristics of the Nation's highways. Its primary purpose is to provide data needed for FHWA to prepare the biennial Conditions and Performance report to Congress. Although it is not perfect and sometimes not complete, the HPMS provides the most up-to-date, nearly national data source on pavement condition and performance.

In its final rule, published in January 2017, FHWA provided the following measures for the performance of the Nation's highway infrastructure, for which data from the NBI database and the HPMS will be used:

- Percentage of interstate system pavements in "Good" and "Poor" condition
- Percentage of noninterstate National Highway System pavements in "Good" and "Poor" condition
- Percentage of National Highway System bridges classified as being in "Good" and "Poor" condition

Taken together, these measures will help tell the story on infrastructure condition in the United States and provide support for any additional funding that might be needed in this area.

System Performance Management Rules

The third TPM final rule, published in January 2017,* presented measures to assess performance of the National Highway System, including the interstate system; freight movement on the interstate system; and traffic congestion and onroad mobile source emissions for the purposes of carrying out the Congestion Mitigation and Air Quality Improvement Program.

For this third TPM rule, for most of the measures, FHWA required the use of the National Performance Management Research Data Set, a federally provided dataset of average travel times. It gathers information from vehicles that periodically report speed, position, and heading with GPS electronics. FHWA also allows for the use of an approved equivalent dataset. Together with NBI and HPMS, this dataset will give decisionmakers the information they need to implement a data-driven performance approach for federally funded projects.

This final proposal was the most complicated of all the

During the comment period on the proposed rule on assessing performance, tens of thousands commented that the rule was too vehicle-focused. They wanted to ensure "performance" covered pedestrians, transit riders, and bicyclists, such as this rider on the streets of New York City's East Side. *Photo: © ginamcleanphoto, Shutterstock.*

*The FHWA final rulemaking on national performance measures took effect on May 20, 2017, with the exception of certain portions of the rule pertaining to the measure on the percent change in carbon dioxide emissions from 2017, generated by onroad mobile sources on the National Highway System. The effective date pertaining to that measure has been delayed indefinitely.

performance measures, generating the most comments.

In requiring FHWA to develop performance measures to support system performance, Congress was not prescriptive and left the definition of the performance of the interstate system up to FHWA. The agency chose to define performance initially in terms of vehicle travel times and would later move toward developing a multimodal performance measure after the completion of additional research. Some members of the public did not agree with FHWA and launched several campaigns to ensure that FHWA knew this—submitting more than 8,800 comments to the public docket, comprising more than 96,000 individual comments.

The following is a summary of these comments:

- The proposal is too *vehicle focused*. Many commenters were concerned that seven of the eight proposed measures were based on data on vehicle travel times.
- FHWA should *account for all people*. The largest volume of comments expressed concern that the proposed measures did not appear to reflect the travel experience of all people using the system. In particular, these commenters were concerned about those using public transportation, walking, or bicycling.
- Waiting for a future *multimodal travel* measure is not enough. Many commenters noted that the proposed measures would encourage highway expansion and would not recognize strategies that provide for greater transportation choices. They maintained that FHWA should use existing data sources to account for all modes of travel.
- The calculation process is *overly complex*. Many DOTs and MPOs raised concerns about the complexity of the measure calculations and asked FHWA to simplify the method.
- The level of *coordination* required. Many DOTs and MPOs expressed concern regarding the level of coordination required to agree on data sources, travel time expectations, and targets for urbanized areas.
- The inclusion of *greenhouse gas emissions*. Comments both supported and opposed the inclusion of a greenhouse gas emissions measure in the final rule. In addition, FHWA received letters from Members of Congress both in support of and against including a greenhouse gas measure, as well as questioning the agency's statutory authority to address greenhouse gas emissions.

As a result of FHWA's review and analysis, the third final rule included the following six performance measures:

- Two measures for system performance:
  - — A measure that will assess the percent of reliable person-miles traveled on the interstate system
  - — A measure that will assess the percent of reliable person-miles traveled on the noninterstate National Highway System
- A measure that will evaluate truck travel time reliability on the interstate system (average truck reliability index)
- Three measures to assess the Congestion Mitigation and Air Quality Improvement program:
  - — A measure that will assess modal share: specifically, the percent of non-single-occupancy vehicle travel that includes travel avoided by telecommuting
  - — A measure that will assess annual hours of peak hour excessive delay per capita
  - — A measure to assess the attainment of national air quality standards in nonattainment and maintenance areas (total emission reductions for applicable criteria pollutants)

Whether a light rail train in downtown Dallas, the San Francisco Muni Bus, a subway, or other variations, transit is a key to multimodal performance management in cities, not only for moving people but also improving air quality. *Photo: © Ken Hurst, Shutterstock.*

One goal of performance management measures is to improve the movement of freight, like these trucks crossing Utah, as a way to strengthen the ability of rural communities to access national and international trade markets and support regional economic development. *Photo: © Vitpho, Shutterstock.*

The Use of Data in TPM

Transportation performance management is not simply about gathering data. No matter how accurate data collection is or will be, it is of little value if officials do not use the data in their decisionmaking to answer the simple question that Secretary Houston raised more than 100 years ago: Are we giving our taxpayers a dollar's result for every dollar we expend for roads?

TPM uses existing data in new ways to ensure that the selection and development of projects actually result in improved performance. Without a way to measure it, progress can be subjective or stated in platitudes. The data collected for TPM will help officials meet performance targets, make decisions on appropriate funding levels, and, in the inevitable ups-and-downs of project development, course-correct over time when targets are not met.

That is what TPM is all about—being accountable for every dollar that is spent on improvements to the Nation's transportation network. As FHWA Associate Administrator for Infrastructure Thomas D. Everett puts it, "TPM introduces a formal way to assess the results of transportation investments. For many years, we have looked at data globally and assumed that our investments were contributing to observed trends in conditions. Under TPM, we will be able to more conclusively determine if we are getting the results we want from the investments we make."

Using existing data systems for the implementation of TPM instead of creating new data sources will help State DOTs and MPOs put funding where it is really needed with a minimum of disruption or delay. The DOTs, which have used the NBI and HPMS datasets for years, are fully familiar with them.

During the rulemaking process, FHWA began planning for the next steps.

TPM Implementation

As planning began for the TPM transition, FHWA undertook a major effort to build capacity among agency staff, DOTs, and MPOs. This capacity-building effort has resulted in the development of tools to assess gaps in knowledge. It has also included webinars and presentations to help FHWA's partners identify noteworthy practices and resources, and to align their business practices with a performance-based approach.

The following are some of the TPM implementation tools.

Development of TPM Training Courses

FHWA is developing a suite of National Highway Institute courses to assist with implementation. Some of the courses will provide overviews, while others are more specific to the FHWA final rules.

The TPM Web site includes additional resources, such as a training video on safety performance management. This 28-minute video, produced in collaboration with NHTSA, is part of the 1-day Safety

National Highway Institute Courses on TPM

1. NHI-138004: MAP-21 Transportation Performance Management Overview (Including FAST Act Updates)
2. NHI-138005: MAP-21 Transportation Performance Management Overview (Including FAST Act Updates) (Web-based)
3. NHI-138006: Transportation Performance Management for Safety
4. NHI-138007: Performance-Based Planning and Programming
5. NHI-138008: Transportation Performance Management for Bridges
6. NHI-138009: Transportation Performance Management for Pavement
7. NHI-138010: Transportation Performance Management for Congestion (Including Freight)
8. NHI-138011: The Role of Data in MAP-21 Transportation Performance Management
9. NHI-138012: Steps to Effective Target Setting for Transportation Performance Management

FHWA has posted descriptions of these courses at www.fhwa.dot.gov/tpm/resources/training.cfm.

Target Setting and Coordination Workshops that FHWA is offering to DOTs, MPOs, State highway safety offices, and other safety stakeholders. The video is available at https://connectdot.connectsolutions.com/p25o3zrj21b.

TPM Technical Assistance Program

This program assists DOTs, MPOs, and transit agencies in a collaborative way that reflects FHWA's approach to the implementation of performance management. The program is founded on the following key outcomes:

- Understanding the state of the practice
- Identifying what is needed to improve the state of the practice
- Providing tools that fill these needs, such as a TPM guidebook, a capability maturity model that gives transportation agencies a framework for assessing strengths and weaknesses as well as ways of improving capabilities, and a TPM toolbox that integrates the model and the guidebook
- Demonstrating progress
- Spurring implementation of TPM principles nationwide

For more information on available technical assistance, as well as resources under development, visit www.fhwa.dot.gov/tpm.

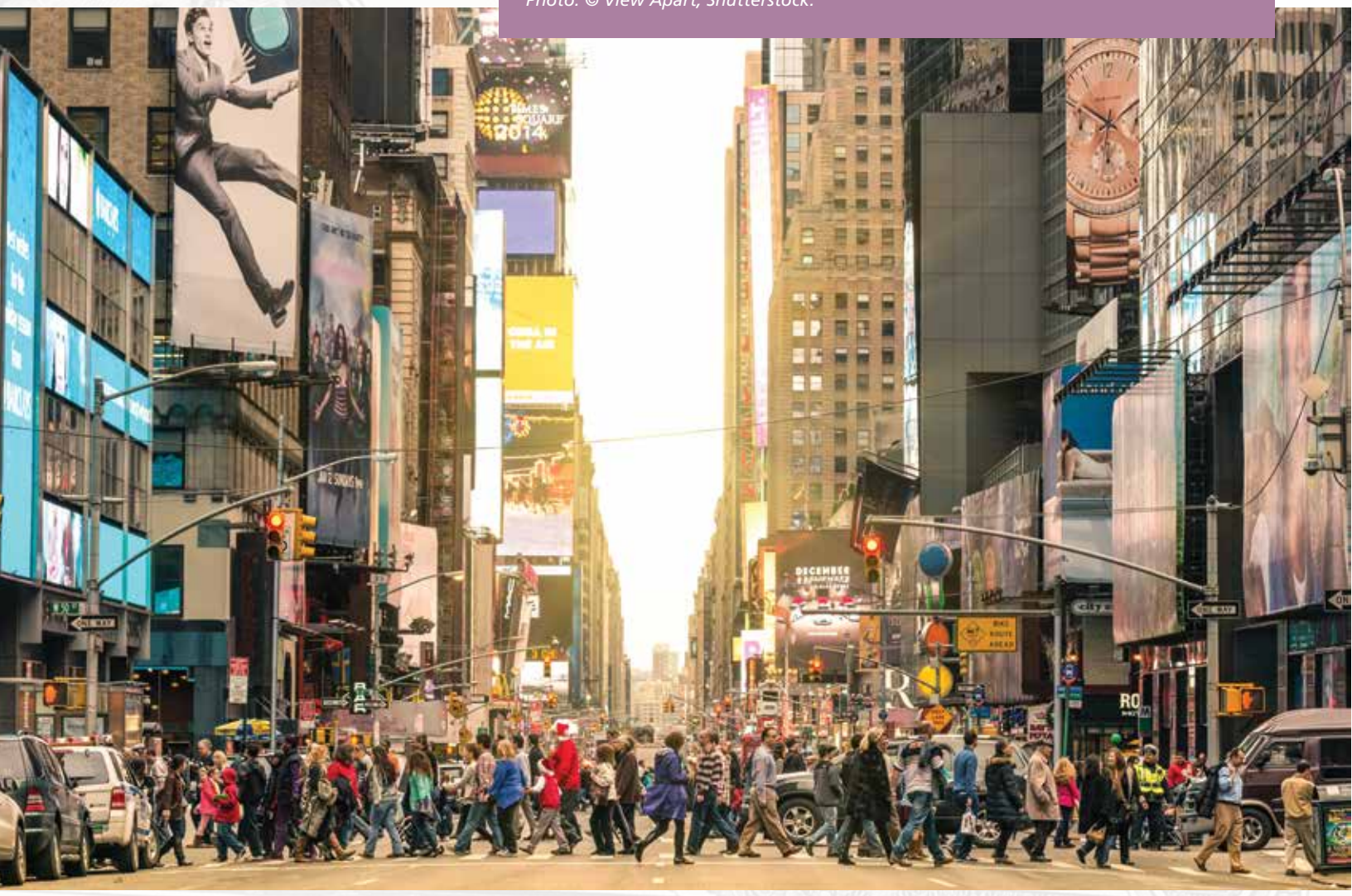
TPM Pooled Fund for Capacity Development

The Rhode Island Department of Transportation, with support from FHWA, developed a pooled-fund project (TPF-5(326), www.pooledfund.org/Details/Study/575) that the American Association of State Highway and Transportation Officials is managing, bringing together State DOTs, MPOs, and Federal partners. Participating members will define training and technical assistance needs, make training available to pooled-fund members, and work with AASHTO's leadership to develop a clearinghouse of TPM resources. FHWA will use input from this partnership to identify future training and assistance to be developed at the Federal level.

TPM Program Guidance

In addition, FHWA has begun developing TPM program guidance on such subjects as reporting requirements, target setting for the long term, and integrating elements of other plans (such as asset

The final performance measure rules include metrics to understand how people travel, including these pedestrians crossing 7th Avenue in Manhattan, and the effectiveness of transportation investments to meet those needs.
Photo: © View Apart, Shutterstock.



For motorists in urbanized areas, congestion, as shown here in Maryland, is one of the most universally despised measures of performance frustration. One goal of the performance management rulemaking is to achieve a significant reduction in congestion on the National Highway System. *Photo: © Andrea Izzotti, Shutterstock.*

management, State freight plans, and State highway safety plans) into the planning process. FHWA is preparing three guidebooks:

Transportation Investment Strategy Analysis Guidebook. This publication will provide comprehensive guidance on how to develop and evaluate investment strategies. It will contain details on evaluating system needs using available tools while coordinating them with the priorities of leaders and stakeholders. The guidance will include a feedback process on evaluating system-level needs and identifying project-level alternatives. The guidebook also will discuss funding sources and how they can support or influence investment strategies.

TPM Target Setting Coordination Guidebook. This publication will provide details on the process of setting common targets among organizations. The focus is on establishing a process for coordinating targets and providing an overlap with existing coordination guidance.

Analytical Tools for Transportation Performance Management. This guidebook will provide details on analytical tools and how to use them in TPM. The focus will be on tools that are available free of charge. Examples include FHWA's Tool for Operations Benefit Cost Analysis (TOPS-BC) available at www.ops.fhwa.dot.gov/plan4ops/topsbctool, Highway Economic Requirements System–State Version (HERS-ST), and National Bridge Investment Analysis System (NBIAS); the Transportation Research Board's *Highway Capacity Manual*; and AASHTO's *Highway Safety Manual*. Additional discussion will cover travel demand models and financial data. Furthermore, the guidebook will provide information on how output from analytical tools such as these can support guidance found in the *Transportation Investment Strategy Guidebook*.

For the majority of TPM program guidance, FHWA intends to provide a 30-day *Federal Register* notice and comment period prior to finalizing the guidance. This procedure will seek to improve guidance implementation by allowing State DOTs and MPOs, as well as others, the opportunity to preview TPM guidance before FHWA finalizes it.

TPM Program Stewardship And Oversight

Following enactment of MAP-21 in 2012, then Executive Director Jeffrey F. Paniati gave FHWA a mandate that the new TPM program would be "stewardship heavy but oversight light" to ensure the agency's partners would embrace their TPM responsibilities without FHWA looking over their shoulders at every turn. It is from this perspective that FHWA has approached the TPM program. In Paniati's words, "Our job is to help make the States and MPOs successful in implementing TPM."

With that thought in mind, FHWA will continue to do all that the agency can to make implementation as easy as possible, while also ensuring that TPM achieves its goal of providing the most efficient means of investing transportation dollars.

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Help Wanted

by Clark Martin and Alexandra Dudley

The transportation industry is leading the effort to recruit and train workers to fill a growing number of jobs. The future of transportation depends on these endeavors.

The transportation system in the United States is a cornerstone of the country's economic growth and prosperity. The system facilitates travel for work, school, and other everyday needs for mobility. The efficiency of the transportation system is dependent on the skills, knowledge, and abilities of the workforce that develops, delivers, and manages its many operations. However, today's transportation workforce is facing several challenges, including difficulty in filling job openings.

The retirement of workers from the "baby boom" generation, an increase in competition from other industries, and new technologies that are driving the need for enhanced skill sets are among the primary factors driving the critical need for new skilled workers. A highly skilled workforce is necessary to address the rapidly evolving areas of automation, information technology, autonomous vehicle technologies, intelligent transportation systems, environmental stewardship, facility and system design, and an expanding global economy.

In August 2015, the U.S. Departments of Transportation, Education, and Labor released a joint report titled *Strengthening Skills Training and Career Pathways Across the Transportation Industry*. The report analyzes future job needs in the transportation industry. According to the report, the transportation industry will need to hire 4.6 million workers from 2012 to 2022—the equivalent of 1.2 times the size of the current workforce. Of those 4.6 million workers, 417,000 jobs are projected to be related to industry growth and 4.2 million are related to separations, which includes retirements, occupational transfers, and other exits from the industry.

In addition to hiring, the industry must ensure that the new hires are well-trained and prepared to deliver the Nation's transportation system.

(Left) A well-trained workforce is critical to completing transportation construction projects throughout the United States, such as this bridge under construction in Louisiana, and to maintaining the transportation system. *Photo: Matthew Cullen, Louisville Paving and Construction.*

The Demographic Cliff

In 2014, approximately 53 percent of transportation workers were over the age of 45 years. As the majority of the transportation workforce nears full retirement age, further workforce challenges emerge. Baby boomers (those born between 1946 and 1964) have already begun leaving the workforce. By 2024, they will be between the ages of 60 and 78.

Not only is the retirement of the baby boomer generation already leading to a significant number of job openings, but it also will mean loss of valuable knowledge and experience. As baby boomers retire, younger workers need to fill their jobs. However, not enough workers are completing the training and educational programs required to fill these positions, posing a challenge for the transportation industry. Without a sufficient number of skilled workers, the industry will have difficulty designing, constructing, and maintaining an efficient, effective, and safe transportation system.

Through 2022, projected annual job openings are approximately 68 percent greater than the number of individuals who are completing transportation-related education and training programs each year. This disparity highlights the gap that the transportation industry needs to address to meet anticipated industry demand. Without effective action, the industry will continue to experience a shortage of qualified workers with the skills necessary to fill the projected job vacancies.

The highway sector has its own set of workforce challenges. U.S. travelers rely on U.S. highways. The National Highway System has more than 4 million miles (6.4 million kilometers) and slightly more than 144,000 bridges. To better understand the highway construction industry's workforce challenges, the Associated General Contractors of America (AGC) conducts an annual survey of its member companies. The 2016 survey, which received more than 1,400 responses, showed that construction firms throughout the country are struggling to fill open positions and hire a sufficient number of qualified workers to meet their needs. Difficulty filling positions directly impacts firms' ability to deliver projects on time and potentially delays repairs needed on the transportation system.

"Putting new workforce development measures in place will make it easier for construction firms to keep pace with growing public- and private-sector demand," says Stephen E. Sandherr, chief executive officer of AGC.

Contractor Job Openings by Position Type

Position	Percent of Firms Struggling to Fill Openings
Carpenters	60
Electricians	53
Concrete Workers	49
Laborers	44
Equipment Operators	43
Cement Masons	42
Iron Workers	40
Truck Drivers	36

Source: Associated General Contractors of America, 2016 Workforce Survey.

Focused Efforts

To avert a potential crisis, the Federal Highway Administration is working in conjunction with other public agencies and private companies and organizations to attract, educate, train, and retain a qualified highway construction workforce. Many government agencies, local organizations, and employers have formed partnerships, developed training and educational programs, and filled job openings. Continued collaboration and leveraging of resources will be necessary to meet future demands for skilled labor.

Through its Center for Transportation Workforce Development, FHWA is bringing together key

Matthew Cullen, Louisville Paving and Construction

Proper construction techniques, such as the girder setting shown here, require specialized skill sets for the transportation workforce.

partners to develop and implement a focused effort: the Highway Construction Workforce Pilot. This pilot program is a joint effort with the American Association of State Highway and Transportation Officials (AASHTO), Associated General Contractors of America, American Road & Transportation Builders Association (ARTBA), U.S. Department of Labor's (DOL) Employment and Training Administration, State and local workforce development boards, and other local labor and workforce development organizations. The effort aims to identify, train, and place individuals in high-need highway construction jobs in 12 pilot locations throughout the country. The pilot program will support on-the-job training criteria in highway construction occupations and will explore how to more effectively link qualified applicants with workforce opportunities in highway construction. AASHTO, AGC, ARTBA, DOL, and FHWA established the Highway Construction Workforce Pilot and are working together as the National Partners Group.

"We know there are a lot of people out there who would excel in these jobs, but finding those individuals has been a challenge," says Brian Deery, senior director in AGC's Highway & Transportation Division. "Our partners on the [workforce development] side can help us with that. The pilot program shows a lot of promise to change the way we address workforce development in the highway construction industry."

The partners have selected six cities (Atlanta, GA; Dallas, TX; Denver, CO; Los Angeles, CA; Pittsburgh, PA; and St. Louis, MO) and six States (Alabama, Arizona, Connecticut, Idaho, Rhode Island, and South Dakota) to participate in the pilot. The locations were chosen based on consideration of several factors, including workforce data, a mix of cities and States, union and nonunion operations, State or local association member organization, and established relationships with State or local workforce development boards.

"The highway infrastructure is critical to our way of life, and there are a lot of good jobs in the highway industry," says Byron Zuidema, deputy assistant secretary for the DOL Employment and Training Administration. "Partnering with the industry to make better use of the publicly funded workforce development system will help job seekers receive the skills and training they need to get placed in those jobs."

How does the pilot program work? At the local level, contractors identify the high-need job occupations they are struggling to fill. Workforce development boards (WDBs) and other local labor organizations identify available training programs and resources, as well as potential participants. Through the pilot program, individuals learn a skill or build on existing skills to begin or enhance a career in the transportation industry, and employers have a larger, more

Workforce Initiatives by the Department of Labor

To address anticipated workforce challenges facing the Nation as a whole, the U.S. Department of Labor (DOL) has funded several initiatives.

American Apprenticeship Grants. To streamline the efforts of employers, organized labor groups, nonprofits, local governments, and educational institutions, in 2015 the White House, through DOL, awarded $175 million in grants to 46 public-private partnerships. The grantees are expected to train and hire at least 34,000 apprentices in high-growth and high-tech industries over 5 years.

America's Promise Job-Driven Training Grants. In November 2016, DOL announced $111 million in America's Promise grants to 23 regional workforce partnerships in 28 States to connect more than 21,000 Americans to education and indemand jobs.

Trade Adjustment Assistance Community College and Career Training Grant Program. In partnership with the U.S. Department of Education, DOL is helping adults acquire the skills, degrees, and credentials required for high-wage and high-skill employment while also meeting employers' needs. These multiyear grants provide community colleges and other institutions of higher education with funding to expand and improve education and career training programs that can be completed in 2 years or less, are suited for workers who are eligible for training under the TAA [Trade Adjustment Assistance] for Workers program, and prepare participants for employment in high-wage and high-skill occupations.

qualified hiring pool to fill their open jobs and complete projects.

Some pathways to highway construction careers are direct referrals of qualified applicants, WDB-provided skills upgrading or training leading to unsubsidized employment, on-the-job training opportunities, apprenticeship programs, and Job Corps or other youth-development programs. There may also be incumbent worker training or other customized training for current workers, and pathways to help workers progress further in their careers.

"By connecting industry and DOL resources, and making the pilot project a local effort, the partners can positively impact workforce development in each location," says Tony Furst, FHWA's chief innovation officer and director of the FHWA Office of Innovative Program Delivery. Furst also leads the Highway Construction Workforce Pilot for FHWA. "Through these connections, the industry workforce needs will be more effectively and efficiently addressed, and individuals will have the opportunity to start or to build a career for themselves."

Matthew Cullen, Louisville Paving and Construction

Developing a variety of workforce programs will be necessary to address the skills gap and provide for a well-trained and qualified transportation workforce. This construction crew is preparing the bridge for the deck construction stage.

Partnering Makes It Possible

Through the Highway Construction Workforce Pilot, FHWA intends to establish effective working relationships between highway construction interests and the workforce system to identify and advance successful workforce development practices and procedures that cities and States throughout the United States can replicate. The National Partners Group will provide direction and oversight of the pilot project, and a National Operations Group will assist coordination with the city and State working groups that will manage program operations in each pilot location.

Jim Tymon, chief operations officer for AASHTO, represents the association in the National Partners Group. "AASHTO and our State DOT member organizations are excited to work with FHWA and the leading highway contractor organizations, AGC and ARTBA, and their member companies on this critical issue," he says. "AASHTO and State DOTs clearly recognize the importance of a capable highway construction workforce to the timely and efficient delivery of highway projects. We believe the Highway Construction Workforce Pilot will set a new, better defined approach to workforce development in our business, and AASHTO is committed to the program."

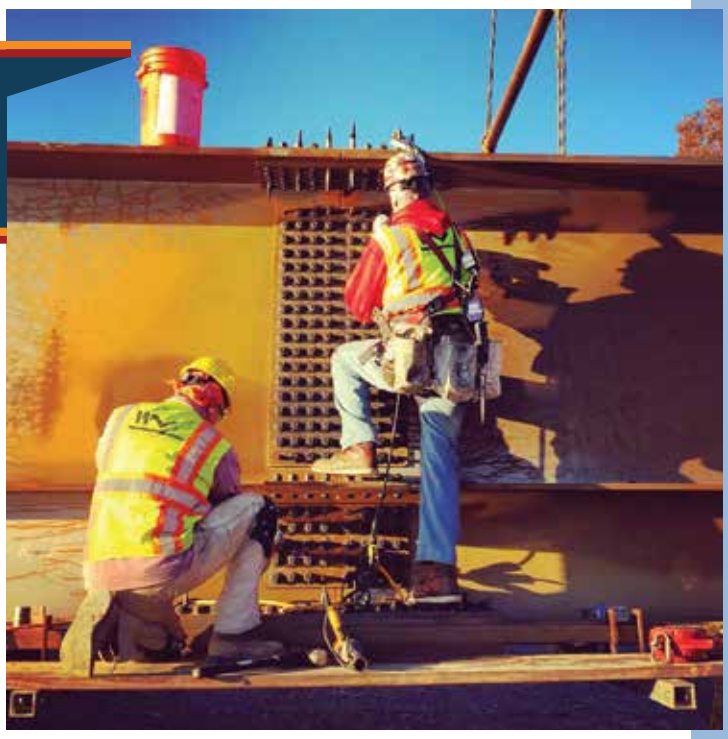
During the course of the project, the National Operations Group will develop a "playbook" that will include specific project plans, best practices, and challenges to aid other locations in their workforce development programs. The objective is for the pilot project to serve as the foundation to institutionalize relationships in workforce development in the highway construction industry.

"We have highway projects in every State and just about every local area of the country," says Rich Juliano, senior vice president of strategic initiatives and managing director of the contractors division at ARTBA, who represents the association on the pilot project. "The city/State pilot location approach will be a good opportunity to adjust our efforts to the specific circumstances in each area. We expect to learn a lot from the pilot project that can be applied to workforce development in support of other highway projects throughout the United States."

Workforce Development At FHWA

In addition to the Highway Construction Workforce Pilot, FHWA is working on other efforts to develop workforce programs and fill the skills gap. In May 2016, FHWA created the Center for Transportation Workforce Development to emphasize workforce issues in the transportation industry. The center provides national leadership, coordination, and assistance to develop and support workforce initiatives throughout the education continuum of K–12, community colleges, universities, and professional development. The workforce center is one of four program-aligned centers that make up the FHWA Office of Innovative Program Delivery. The other centers are the Center for Accelerating Innovation, the Center for Local Aid Support, and the Center for Innovative Finance Support.

"The Federal Highway Administration will continue to focus leadership on areas most critical to the transportation industry and system," says FHWA Acting Deputy Administrator Butch Waidelich. "And with the new workforce center, we have an organization that will provide leadership in working



Matthew Cullen, Louisville Paving and Construction

A sharp focus and precise workmanship, such as that demonstrated by these workers installing a girder splice, is critical to maintaining the public trust in delivering the Nation's highway program.

with key partners in transportation, education, and other workforce interests to leverage activities and resources to enhance transportation workforce development."

The center helps to manage the Highway Construction Workforce Pilot and several other workforce development efforts including the FHWA On-the-Job Supportive Services Program, Eisenhower Fellowship Program, National Summer Transportation Institute Program, Garrett A. Morgan Technology and Transportation Education Program Clearinghouse for K–12 programs, and the five Region Transportation Workforce Centers.

"The increasing focus and leadership on workforce development that the FHWA workforce center provides will improve workforce development at all levels," says Virginia "Ginny" Tsu, director of the Center for Transportation Workforce Development. "Expanding our relationships in workforce development with key partners including DOL through the pilot program, and bringing together the existing FHWA workforce programs provides a powerful combination of resources and assets to make a real difference in workforce development."

An Expanded Effort: Region Centers

In 2014, FHWA created five regional transportation workforce centers—collectively known as the National Network for the Transportation Workforce—to establish a network-driven approach to developing and retaining a highly skilled and effective transportation workforce. Although the regional centers do not provide training, they engage organizations and existing programs to establish new strategic partnerships and promote best practices to educators, employers, and those on the transportation career pathway. For more information on the National Network for the Transportation Workforce, see "Connecting the Employment Dots" in the November/December 2015 issue of PUBLIC ROADS.

"The region workforce centers provide an important network for workforce development that can help identify and facilitate implementation of value-added workforce development programs," says Glenn McRae, director of the Northeast Region Workforce Center based at the University of Vermont. "We are able to work within and across transportation, education, and training interests for the greater benefit of transportation workforce development. Collectively, the National Network for the Transportation Workforce

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Source: FHWA

has already established more than 100 partnerships with transportation and education groups for substantive workforce activities. We will continue to work with FHWA and other key partners to improve workforce development throughout the education continuum."

FHWA recently awarded the National Network for the Transportation Workforce, a cooperative agreement for the National Transportation Career Pathways Initiative, to research and develop career pathways in the key discipline areas of environment, safety, operations, planning, and engineering. Led by the Southwest Transportation Workforce Center located at the California State University, Long Beach, the program will identify key occupations, as well as gaps between available training, education, and experiential learning programs.

The program also will identify elements necessary to develop a highly skilled workforce in each of the five discipline areas. In collaboration with key stakeholders, the National Network for the Transportation Workforce will develop career pathways at technical schools, community colleges, and universities to help fill the skills gap and train individuals in the key occupations.

The National Network for the Transportation Workforce began work on the Career Pathways Initiative, a 2-year program, in October 2016. The Southwest Region Workforce Center will lead a demonstration project in at least one technical school, community college, and university for the planning discipline. The other region workforce centers will complete their work on competencies, curriculum, experiential learning, and design demonstration projects for the disciplines they are managing.

"We need to better align the transportation workforce demand of private and public sector transportation organizations with the workforce supply efforts of education, training, and workforce development," says Tom O'Brien, director of the Southwest Transportation Workforce Center. "A lot of work needs to be done, and the National Network for the Transportation Workforce is looking forward to working with key partners across the transportation, education, and workforce communities on the National Transportation Career Pathways Initiative."

Matthew Cullen, Louisville Paving and Construction

Attracting younger workers to the transportation industry will be crucial to filling job openings over the next 10 years. These workers will help deliver a safe and efficient transportation system, including constructing new infrastructure.

A Present and Growing Need

With the highway industry bracing for shortages of available workers, now is the time for efficient and effective programs focused on recruiting, training, placing, and retaining workers, as well as efforts to better prepare the next generation of workers for transportation jobs.

Positions in the highway industry can lead to promising careers and opportunities for advancement. Although 4-year degrees often are not required for transportation careers, some training and education is necessary to have the skills required for most positions. Current workers and potential new hires in the transportation industry need to have access to and awareness of the available training programs that can help them develop skills to further their careers.

The need will continue to grow as more baby boomers retire and new technologies emerge. The transportation industry must continue to focus on training younger workers and providing them with the necessary knowledge, skills, and experience to deliver a safe, efficient, and effective highway system.

Clark Martin is a program manager for the FHWA Center for Transportation Workforce Development, part of the Office of Innovative Program Delivery. He is a lead manager for FHWA workforce programs and initiatives including the five FHWA-sponsored Region Transportation Workforce Centers, the Highway Construction Workforce Pilot, and the National Transportation Career Pathways Initiative. Martin is a graduate of the University of Maryland with a B.A. in political science.

Alexandra Dudley is a business analyst in the FHWA Center for Transportation Workforce Development. She is very involved with the Highway Construction Workforce Pilot, Region Transportation Workforce Centers, and the National Transportation Career Pathways Initiative. She holds a B.A. in economics and history from William & Mary and an M.S. in commerce from the University of Virginia.

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A Focused Approach to Pedestrian and Bicycle Safety

by Tamara Redmon, Elissa Goughnour, and Kara Peach

FHWA's technical assistance program helps communities protect their most vulnerable road users. Here's how three locations have met the challenge.

Pedestrian fatalities are on the rise, and transportation agencies are finding ways to combat the problem with FHWA's help. *Photo: www.SeeFloridaGo.org.*

In 2015, the most recent year for which data are available, 5,376 pedestrians and 817 bicyclists were killed on U.S. roads—the highest numbers since the mid-1990s. Although pedestrian fatalities had been trending downward for many years, they have been increasing since 2009. Walking and bicycling are vital to all communities, and the Federal Highway Administration recognizes the importance of addressing safety for these vulnerable road users.

For more than a decade, FHWA's Office of Safety has delivered a targeted training and technical assistance program to cities and States with the highest number of pedestrian fatalities. In 2015, FHWA revised the program to emphasize both pedestrians and bicyclists. FHWA updates the program, known as the Focused Approach, with new focus cities and States approximately every 5 years, based on the most current fatality data. When FHWA most recently reevaluated the program in 2015 (using 2013 data), the focus cities accounted for approximately 18 percent of all pedestrian and bicyclist fatalities in the United States.

As a leader in the conversation, FHWA is helping to create a consensus between State and local transportation agencies about how to improve pedestrian and bicycle safety. FHWA provides training and technical assistance to help demonstrate the need to address safety and determine how to move the conversation forward at the regional and State levels.

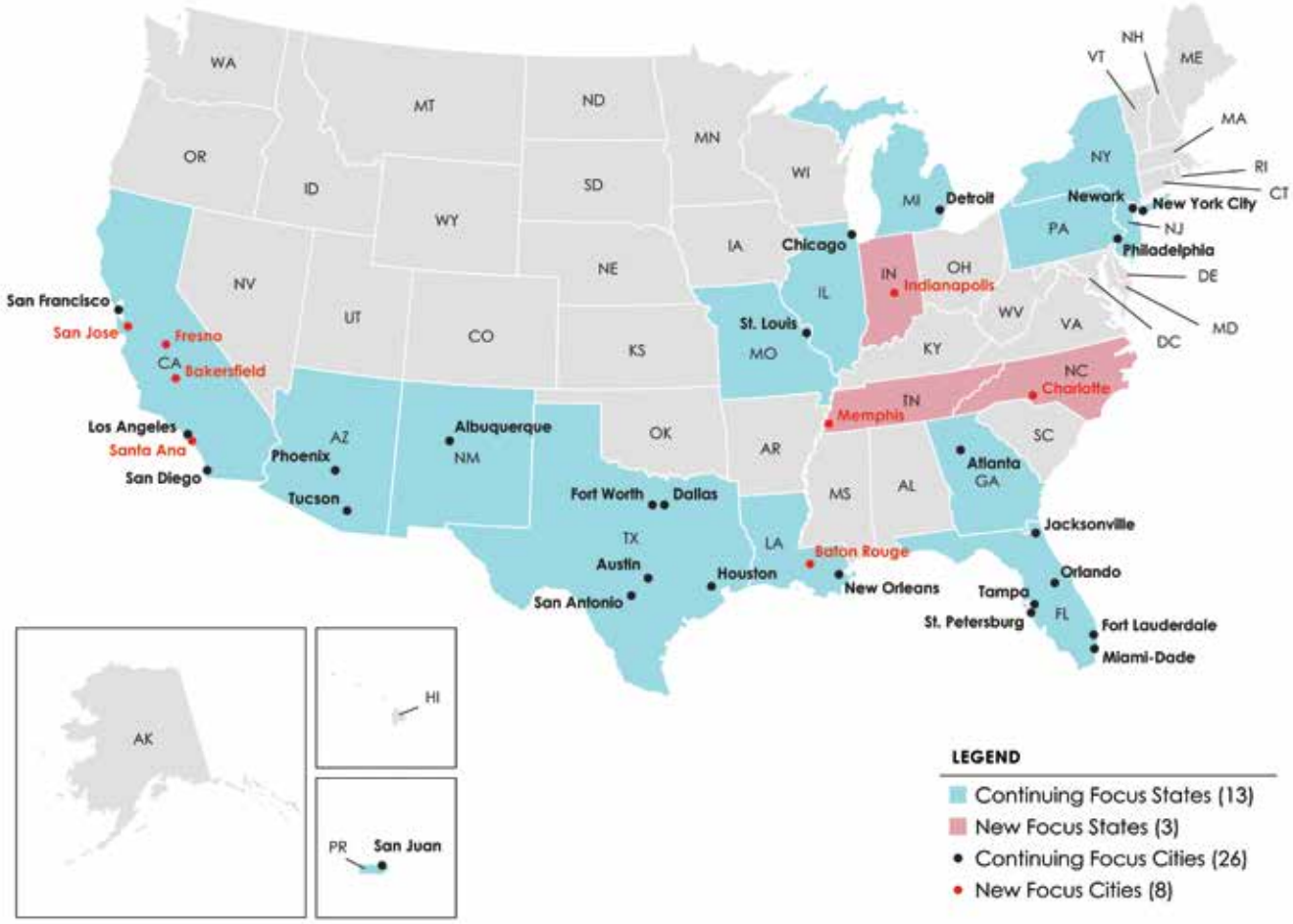
No two agencies are alike, and each participating city and State faces distinct challenges that require a tailored approach to identifying and addressing problems. Read on to learn how three participants in the program—the city of Chicago, the North Central Texas Council of Governments, and the State of Florida—have used different strategies for implementing comprehensive, safety-focused programs to reduce pedestrian and bicyclist injuries and fatalities.

Chicago

In 2016, the city of Chicago announced its citywide Vision Zero Chicago Initiative. This effort expands on the "Zero in Ten" goal set forth in the Chicago Department of Transportation's (CDOT) 2012 *Chicago Pedestrian Plan*, which aims to eliminate pedestrian deaths in 10 years. The new initiative has a broader focus on serious and fatal crashes for all transportation modes in Chicago.

"No one person is more important than others," says Mike Amsden, CDOT's assistant director of transportation planning, "but people walking and biking are the

2015 Pedestrian-Bicycle Focus Cities and States



Source: FHWA.

most vulnerable users of the roadway because [their] crashes are more likely to be serious or fatal."

Although safety is the primary reason for focusing on pedestrian and bicyclist efforts across the city, the decision is also a matter of popularity. More people are walking and bicycling throughout Chicago than in previous years. Similar to other large cities, walking, bicycling, and neighborhood economies all contribute to Chicago's character and success. More than 40 percent of work trips in the city are made via modes other than driving—and the city aims to increase that to 50 percent by 2040.

In order to reduce injuries and fatalities from crashes, CDOT focused on strategies that would help garner investment and support for projects and effective countermeasures from local officials, community members, and businesses. The goals: Chicago should be part of the national dialogue and seek investment from leadership, and must develop and maintain useful and effective plans, build strong relationships, and create a culture of safety across the city.

Implementing Vision Zero Chicago

CDOT staff have drawn on their personal experiences with successful initiatives in other cities, as well as their current and previous engagement with FHWA and national organizations, to bring Chicago into the national dialogue on pedestrian and bicycle safety. In addition, Vision Zero complements a growing data-driven approach to support moving people and improving public health and transportation outcomes.

City leadership has supported the program. In September 2016, Mayor Rahm Emanuel announced the city's continued commitment to saving lives and preventing serious injuries through the launch of Vision Zero. The initiative involves the coordinated efforts of 10 city departments working at the direction of the Office of the Mayor, including CDOT, the Chicago Police Department, and the Department of Public Health.

Moreover, CDOT has worked to foster stronger relationships with the Illinois Department of Transportation. Approximately 40 percent of arterial streets in Chicago fall under the State DOT's jurisdiction, requiring frequent coordination between the agencies. CDOT has worked to demonstrate the effectiveness of implemented countermeasures such as road diets and separated bike lanes. It has also shown success over time based on reduced crash rates and active use of facilities. For example, on the Dearborn Street two-way separated bike lane, from 2010 to 2014 total crashes decreased by 30 percent and bicycle ridership increased by 171 percent. The 55th Street separated bike lane saw a 33-percent reduction in total crashes during the same time period.

In order for CDOT staff to be able move from the plan to implementation, strong leadership and coordination with other departments and community groups are critical. The *Chicago Pedestrian Plan* has many strategies focusing on a variety of initiatives—a number of which involve reinvigorating underutilized spaces, livability, and health outcomes, in addition to improving safety and accessibility. To monitor and implement the goals, CDOT must coordinate with other agencies and organizations. Partners such as the Department of Public Health, Department of Cultural Affairs and Special Events, local chambers of commerce, Chicago Police Department, Chicago Transit Authority, Department of Planning and Development, and Department of Innovation Technology all have been instrumental in implementing the plan.

Tailoring the Approach

Chicago encompasses many neighborhoods, and the built environment affects how people experience the city. It is important to understand the multifaceted relationships among the transportation system, personal and community health and wellness, access to housing, and economics. To accomplish this, CDOT staff look directly to the communities they serve. Their strategies for winning community support and buy-in differ for all projects.

One approach that CDOT has taken is to hire local community members and young adults to spread awareness of transit options. The program focuses on specific neighborhoods with good access to

Chicago implemented a road diet on 55th Street to add a designated bicycle lane and improve safety for all road users. *Photo: Mike Amsden, CDOT.*

Investing in Chicago's Neighborhoods

Improvements to Chicago's Argyle Street demonstrate the city's investment in communities and the people who live there. The street anchors a predominantly Vietnamese and Chinese commercial area on Chicago's North Side, and it has high pedestrian activity and low vehicular traffic. A recently completed streetscape project involved the conversion of a traditional city street into a shared street in which pedestrians have the right-of-way regardless of where they cross or stroll. The project was constructed in coordination with the city, community, and a local alderman. Good communication with residents, along with local presence and involvement, were critical to the project's success. The project team held weekly construction meetings to inform residents of progress, the alderman staffed a satellite office onsite to be responsive to residents' needs, and local champions spoke to residents about how to use the new roadway during and after construction.

Mike Amsden, CDOT

The shared street project on Chicago's Argyle Street, shown here, included the redesign of the sidewalks and travel lanes so that they are on the same level. Pedestrians have the right-of-way.

transit and those with low numbers of people walking, biking, or using transit. The program educates residents on accessing transit, payment options, and route mapping. These educational positions are open to anyone, and CDOT staff members work with community groups and leadership to spread the word about available positions. A travel demand management grant, part of the Federal Congestion Mitigation and Air Quality Improvement (CMAQ) program and administered by the city, supports the program. CMAQ grants require a 20 percent local funding match that comes from a variety of sources, including CDOT.

In addition, a CDOT ambassador program enables youth and young adults throughout the city to educate people on the benefits of walking and bicycling. This effort focuses on traffic safety and provides information about how to walk and bike safely around the city. In order to spread the word, ambassadors attend popular city events such as the annual Chicago Jazz Festival and the 2017 Lollapalooza.

By meeting the demand for enhanced pedestrian and bicycle facilities, and by working with stakeholders from the community up to the State and Federal levels, CDOT contributes to the effort to build a city that creates a sense of place, offers livable neighborhoods, and attracts people, families, and businesses.

North Central Texas Council of Governments

The jurisdiction of the North Central Texas Council of Governments (NCTCOG) spans 16 counties, and the council also serves as the metropolitan planning organization for the Dallas-Fort Worth metropolitan area. Land use, safety concerns, and traffic volumes and speeds vary across the area. And the population continues to grow—NCTCOG estimates 1,000 new schools will be built by 2040. NCTCOG faces the challenge of predicting where the region is heading in the future and how best to meet the needs of everyone.

"Few regions in the United States are similar to that served by [NCTCOG]," says Karla Weaver, manager of the organization's sustainable development program. "NCTCOG covers an area larger than the size of Connecticut [with] over 7 million people and is very urban, very suburban, and very rural. The primary focus is on context: One size does not fit all."

The agency works closely with all municipalities to understand their concerns and needs, and to consider how to foster a culture of safety within the region. NCTCOG uses four key strategies to better facilitate initiatives for pedestrian and bicyclist safety: education and outreach, technical training, funding for engineering solutions, and data collection.

Education and outreach. In order to reach its large and diverse population, NCTCOG has implemented several educational initiatives across the region. For example, a grant from the Texas Department of Transportation (TxDOT) funds a campaign called "Look Out Texans—Bike, Walk, Drive Safely." The effort includes a series of videos that promote the messages that everyone is a pedestrian at some point during the day, and while individuals might not be bicyclists, someone in their social networks may be. The campaign also includes billboards, commercials, radio advertisements, and school and parental resources aimed at encouraging all roadway users to treat one another with respect and to behave safely.

Technical training. NCTCOG plays an important role as a training provider to agencies and cities on the many resources and latest technologies available for transportation planning and safety. Together with FHWA, the agency has offered several well-attended courses on design for pedestrian safety, separated bicycle facilities, complete streets policies and design, and road safety audits, among other topics. Building on these training opportunities, in fall 2017 the city of Fort Worth and

As part of the Look Out Texans campaign, NCTCOG and TxDOT placed billboards on the sides of buses with educational tips for motorists, bicyclists, and pedestrians. *Photo: NCTCOG.*

NCTCOG will begin development of an active transportation plan as a pilot for the region. The plan will layer the city's existing pedestrian, bicycling, thoroughfare, and transit plans. This will enable decisionmakers to identify and prioritize projects with the greatest impact.

Funding for engineering solutions. Transportation agencies continuously face the challenge of finding funds for engineering solutions. NCTCOG strives to identify various funding sources to support its agencies. In 2014, through a multiyear call for projects, NCTCOG awarded more than $38 million in funds from the CMAQ program for active transportation projects. NCTCOG anticipates an additional $34 million in Transportation Alternatives Set-Aside Program funding in a 2017 call for projects. This funding supplements other ongoing CMAQ funds and other funding sources allocated by the Regional Transportation Council each year to active transportation projects in the region.

Because of the high cost of infrastructure and the number of transportation agencies NCTCOG must serve, the agency focuses on top-down safety policies incentivized with funding opportunities. The current long-range transportation plan, *Mobility 2040*, includes an appendix with 20 policies pertaining to roadways, travel demand management, safety, air quality, sustainable development, transportation security and traffic operations, transit, freight, and aviation. Cities, counties, transit agencies, school districts, and TxDOT are eligible to have the local match offset on federally funded projects if they "bundle" policies by adopting a minimum of 50 percent of the listed policies, chosen to meet the organization's specific needs. For example, a city could select complete streets, safe routes to school, clean fleet, and parking management policies, and a county could choose to adopt policies on railroad safety, stormwater management, and unmanned aircraft systems.

Eligible agencies meeting the bundle requirements receive transportation development credits to offset local matching funds that are usually needed on federally funded projects. NCTCOG believes that the short-term cost of offset local funding will result in long-term policies that will improve design and infrastructure in the future.

Data collection. NCTCOG takes the adage "If you are not counted, you do not count" very seriously. Obtaining data for effective decisionmaking is a top priority, and NCTCOG partners closely with local governments to conduct permanent and mobile counts in various facilities around the region. NCTCOG staff have used that data to pinpoint regional hotspots and determine areas with the highest density of short motor vehicle trips in order to identify alternative and safe transportation options. NCTCOG's data initiatives have laid the groundwork for a proactive approach to roadway projects and have facilitated interagency collaboration.

Florida

The State of Florida relies on responsive transportation systems to support safety, mobility, and economic competitiveness. Although Florida's diverse and aging population creates many challenges, the Florida Department of Transportation (FDOT) understands the important role that active transportation plays in providing essential mobility for many residents. FDOT recognizes that safe and accessible facilities for walking and biking bolster

Local bicycle shops were key partners in NCTCOG's community outreach initiative, placing hangers designed by TxDOT with relevant bicycle safety information on all new purchases and repairs, as well as distributing local and regional trail maps. *Photo: NCTCOG.*

Older Adults and Intersections

One example of Florida's integrated four E's approach involves older adults crossing at large intersections. Through its research, FDOT found that older adults are easily intimidated by larger intersections and tend to cross midblock, outside of a crosswalk, putting them at greater risk of being struck by a vehicle. To assist these pedestrians, FDOT developed a combined engineering and educational strategy that included implementing leading pedestrian interval phasing, which gives pedestrians a head start of several seconds to begin crossing before the signal turns green for vehicles at larger intersections, enabling pedestrians to cross before vehicles get the green signal. In addition, FDOT circulated educational information to the older population about the benefits of using crosswalks, as well as instructions for safe crossings.

www.SeeFloridaGo.org

community mobility, vibrancy, and public health; strengthen local economies; and improve quality of life.

As factors such as travel demand or crash risk increase or change over time, management and operation of Florida's multimodal transportation system also change. This was the case for pedestrian safety when, in 2004, FHWA designated Florida as a pedestrian focus State because of the high proportion of statewide pedestrian fatalities, and in both 2009 and 2011, when Smart Growth America released the *Dangerous by Design* report ranking four Florida cities as the most dangerous in the Nation for pedestrians. These rankings led to prioritizing pedestrian and bicycle safety within the State.

Working to cohesively address pedestrian and bicycle safety challenges, FDOT established a plan for resolution. In November 2011, the State convened a focused initiative leadership team and, in partnership with the National Highway Traffic Safety Administration, conducted an assessment to determine current and future efforts to improve the safety of vulnerable users.

Florida used the assessment results to develop the State's first *Pedestrian and Bicycle Strategic Safety Plan*, published in February 2013, and to launch its Pedestrian and Bicycle Safety Coalition. The coalition is charged with implementing strategies that improve the safety, mobility, and accessibility of pedestrians and bicyclists in Florida. The coalition's resulting campaign, Alert Today Alive Tomorrow, promotes a consistent and recognizable safety message that is widely recognized as *the* pedestrian and bicycle safety program, rather than *FDOT's program*. All partners and stakeholders have a sense of investment and ownership.

"Our mission is to provide a safe and accessible transportation system where people of all ages and abilities can walk, bike, or utilize transit safely," says Trenda McPherson, FDOT's manager for the Bicycle Pedestrian Safety Program. "We are ultimately improving the quality of life for our residents and visitors while promoting a healthy economy in Florida."

A Cohesive Program

Florida takes a comprehensive approach to problem resolution, including educating the public, enforcing traffic laws, improving emergency response, and planning, designing, and engineering projects based on the context of the community where the project is located. Unlike other areas, there are no boundaries between the "four E's" of engineering, enforcement, education, and emergency services. Instead, they are combined and overlapped to provide the greatest opportunity to improve safety at every level.

Engineering is an important factor in the State's pedestrian and bicyclist strategic safety plan. About half of the roads in Florida are State roads and half are local, so buy-in from local agencies is important. FHWA also has been an integral partner in offering workshops on designing for pedestrian and bicycle safety, road safety audits, and law enforcement trainings to support the effort. In addition, FDOT conducts a free, annual design conference and routinely works with State and local agencies on specific challenges.

Education is not limited to engineering staff. FDOT partners with providers of emergency medical services and trauma centers to identify the most common types of injuries when pedestrians and bicyclists are involved in traffic crashes. Working together, the partners identified strategies for improving emergency response and treatment at various stages of the medical process and delivered training to medical staff in an effort to increase survival rates for these crash victims.

Through FDOT's Highway Safety Grant program, the University of South Florida's Center for Urban Transportation Research tests education and communication strategies using focus groups, observations, and surveys to ensure that messages resonate with the intended audience. FDOT then implements a culturally diverse and customized marketing strategy, working with local partners to reach residents in the appropriate language with the appropriate messages.

For example, Alert Tonight Florida's Can You See Me Now? campaign provides bicycle lights to students in lower socioeconomic areas to improve riders' safety and visibility.

The Discover Your Role initiative, part of FDOT's Alert Today Alive Tomorrow campaign, employs an innovative strategy to encourage sharing the road. Developed by Polk County, a local government partner that works with FDOT on the safety initiative, this campaign includes a variety of materials targeting different roadway users and highlighting the need to identify their role in keeping each other safe on the road.

In addition to the fluid overlap and integration of the four E's, FDOT's Pedestrian and Bicycle Safety program considers the context of the community when selecting and implementing countermeasures. More than half of the residents of Miami-Dade County emigrated from another country where traffic laws or customs may have been different. Considering *how* and *where* people use the roadway, cultural differences, socioeconomics, and age all play important roles in shifting behavior and improving safety on Florida's roads.

Continuously Adapting

The focus sites have made great progress in improving pedestrian and bicyclist safety with assistance from FHWA's Focused Approach program. FHWA's most recent assessment of the program, in 2016, showed that between 2007 and 2012, Florida's efforts resulted in a 17-percent reduction in pedestrian crashes, with Miami, Orlando, and Tampa each reducing crashes by 38 to 44 percent. Chicago also reduced pedestrian crashes by 17 percent during the same time period. (Efforts in the Dallas/Fort Worth area are more recent, so data are not currently available.)

"FHWA must continue to adapt to the needs of States and cities charged with protecting the most vulnerable road users, as we have for the past 13 years," says Elizabeth Alicandri, FHWA's associate administrator for safety. "For instance, when we began this program, there was more of a focus on States, but we came to realize that cities have greater pedestrian and bicyclist safety challenges."

FHWA has adapted the approach in other ways as well. Over the years, the agency has developed several courses and workshops, and has added to the menu of training options available based on the needs of the focus cities and States. For example, once bicyclist safety was added to the program, FHWA developed additional training on designing for bicyclist safety, as well as addressing safety for pedestrians and bicyclists in the context of complete streets planning and design. FHWA also is in the process of updating its *How to Develop a Pedestrian Safety Action Plan* (FHWA-SA-05-12) to help agencies reduce pedestrian and bicyclist fatalities.

As noted in FHWA's 2016 *Strategic Agenda for Pedestrian and Bicycle Transportation* (FHWA-HEP-16-086): "USDOT is committed to making all travel modes, including walking and bicycling, safe, accessible, comfortable, and convenient for everyone."

Rolled out in 2013 in 10 counties, Florida's Alert Today Alive Tomorrow campaign includes TV, radio, social media, and transit advertising, as well as local education and enforcement activities. *Photo: FDOT.*

Tamara Redmon is the pedestrian safety program manager in FHWA's Office of Safety. She has managed the Pedestrian and Bicycle Safety Focused Approach Program for 13 years. She has a B.A. in English from Virginia Tech and an M.A. in human resource management from Marymount University.

Elissa Goughnour is a transportation safety project manager for VHB. She has 15 years of experience in transportation safety, design, and analysis. She holds a B.A. in environmental studies from Gettysburg College and an M.S. in civil engineering from George Mason University.

Kara Peach is a transportation planner at VHB with experience in highway safety and transportation planning. She has a B.A. in psychology from Indiana University and an M.A. in psychology of sport and physical activity from the University of Iowa.

For more information, visit http://safety.fhwa.dot.gov/ped_bike/ped_focus or contact Tamara Redmon at 202-366-4077 or tamara.redmon@dot.gov.

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 sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

Technical News

EAR Program Publishes Updated Research Results

The Federal Highway Administration's Exploratory Advanced Research (EAR) Program addresses the need for longer term, higher risk research with the potential for long-term improvements to transportation systems. In February, FHWA published *EAR Program Research Results: Updated through 2016* (FHWA-HRT-17-021), a catalog documenting the output of the program's investments in five areas where changes in science and engineering can dramatically lead to making the highway system safer, more durable, and more efficient.

The publication is organized using these investment areas: (1) connected highway and vehicle system concepts, (2) breakthrough concepts in materials science, (3) human behavior and travel choices, (4) technology for assessing performance, and (5) new technology and advanced policies for energy and resource conservation. Through 8 solicitations, the EAR Program has awarded 79 projects involving both government and academic researchers. These projects represent the investment of $76 million in FHWA funds and leverage $28 million in matching funds.

The results of these projects may lead to new research methods, models, or data that can accelerate applied research or new system concepts or prototypes, including laboratory testing or limited field testing. The EAR Program does not fund projects through commercialization or deployment. Rather, results must be taken up by the research community, with the support of other funding sources. FHWA is committed to transitioning the results of EAR Program-funded projects from the lab to real-world applications and takes an active role in demonstrating results to audiences who are critical to continuing the research and development cycle.

For more information, visit www.fhwa.dot.gov/advancedresearch. The report is available at www.fhwa.dot.gov/advancedresearch/pubs/17021/17021.pdf.

Public Information and Information Exchange

USDOT Announces 2017 SBIR Awardees

Small businesses continue to help USDOT address some of the Nation's biggest transportation challenges through the Department's Small Business Innovation Research (SBIR) program. This highly competitive, awards-based program is a key catalyst for domestic small businesses to engage in transportation-related research and development. In March, the program recommended awarding 14 small businesses under the latest SBIR solicitation.

SBIR
America's Seed Fund
POWERED BY DOT

USDOT received a total of 106 proposals for the 9 topics covered in the solicitation. Together, the selected businesses will receive a combined $1.9 million for their phase I concept development addressing challenges including broken rail detection, tetrahydrocannabinol (THC) detection devices, and information tools for transit users. Through this conceptual development phase, the small businesses will determine the potential for commercializing their research in order to receive additional funding in phase II.

The goals of the SBIR program include meeting Federal research and development needs, increasing private sector commercialization of innovations derived from Federal research and development funding, stimulating technological innovation, and fostering and encouraging participation in innovation and entrepreneurship by socially and economically disadvantaged persons.

For more information, visit www.volpe.dot.gov/work-with-us/small-business-innovation-research.

Volpe National Transportation Systems Center

Handbook and Case Studies on Regional Models of Cooperation Now Available

FHWA recently published the *Regional Models of Cooperation Handbook* (FHWA-HEP-17-030), as well as two new summaries from peer exchange workshops in Alaska and Utah. The Regional Models of Cooperation program is co-led by the FHWA Office of Planning and the Federal Transit Administration Office of Planning and Environment and was part of the third round of FHWA's Every Day Counts initiative.

The handbook describes notable practices used by State departments of transportation, metropolitan planning organizations, transit agencies, and other partners that work across jurisdiction boundaries or traditional disciplines to enhance transportation planning. It offers a framework for how to think about opportunities for regional cooperation, presents 20 case studies of how

and why peer agencies have chosen to work together, and provides tools and resources that agencies may consider adapting for use in their own regions.

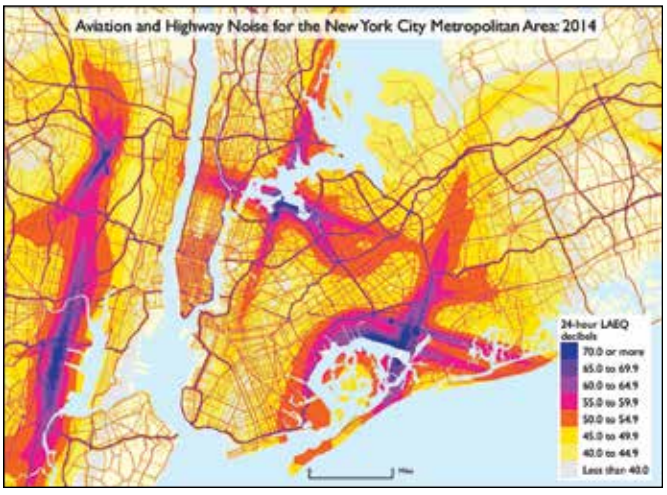
FHWA also released two workshop summaries, adding to the three previous summaries published in 2016. *Regional Cooperation and Transportation Planning in Alaska* (FHWA-HEP-17-039) summarizes the presentations, key themes, and recommendations identified at a virtual peer exchange held March 9 and 10, 2016. The FHWA Alaska Division Office hosted peers from the Center for Community in Sitka, AK; the New Mexico Department of Transportation; the Nashua Regional Planning Commission in New Hampshire; and the National Park Service's Alaska Regional Office.

Regional Cooperation and Bike/Ped and Transit Connections (FHWA-HEP-17-041) highlights key themes identified at a peer exchange held on October 24, 2016, in Salt Lake City, UT. For that event, the Utah Transit Authority hosted peers from the Los Angeles Metropolitan Transit Authority and the Mid-America Regional Council.

For more information, visit www.fhwa.dot.gov/planning/regional_models.

BTS and Volpe Create Transportation Noise Map

Noise levels associated with different kinds of traffic—whether from motor vehicles on roadways, ships maneuvering in waterways, trains passing through rail corridors, or planes in the sky—affect communities and natural environments across the country. With the U.S. population expected to grow by more than 100 million by 2050, heightened transportation demands could increase the burden of high noise levels.



This map, generated using the National Transportation Noise Mapping Tool, shows noise levels related to aviation and highways in the New York City metropolitan area, according to 2014 data. *Source: Office of the Assistant Secretary for Research and Development.*

To better understand roadway and aviation transportation noise levels and their potential effects, USDOT's Bureau of Transportation Statistics (BTS), with assistance from a team of researchers at Volpe, recently released the National Transportation Noise Map. The tool offers the first national, multimodal, transportation-focused geodatabase with modeled noise levels. It includes GIS layers that enable users to view aviation and road noise separately or cumulatively. The yearly trends that the tool can provide will be particularly useful to policymakers and community planners in understanding the impacts of noise levels.

The initial map shows that more than 97 percent of the U.S. population has the potential to be exposed to noise from aviation and interstate highways at levels below 50 decibels—roughly comparable to the noise level of a humming refrigerator. Less than one-tenth of a percent of the population could potentially experience noise levels of 80 decibels or more, equivalent to the noise level of a garbage disposal.

The map is an addition to the National Transportation Atlas Database, a set of nationwide geographic databases of transportation facilities, networks, and associated infrastructure available from the BTS Geospatial Data Catalog. The layers will be updated on an annual basis, and developers anticipate including additional transportation noise sources, such as rail and maritime, in future versions.

For more information, visit https://maps.bts.dot.gov or contact Ed Strocko at ed.strocko@dot.gov.

BTS

NTSB Releases Drowsy Driving Alert for Teens

According to the Centers for Disease Control and Prevention, motor vehicle crashes are the leading cause of death for teens in the United States. Further, recent research by the AAA Foundation for Traffic Safety shows that one in five fatal crashes involves a drowsy driver. Other research shows that drivers between the ages of 16 and 24 are at the greatest risk of being involved in a drowsy driving crash.

NTSB

The teenage driver of this wrecked car crossed the median and collided with a freight truck in Robstown, TX, in March 2016. The NTSB investigated and determined that the probable cause of the crash was "the loss of control by the driver of the [car], due to inattention resulting from fatigue."

To call attention to the risks posed by driving drowsy, the National Transportation Safety Board (NTSB) recently released a safety alert, *Drowsy Driving Among Young Drivers*. The alert underscores the problem, shares the latest statistics, and offers recommendations to minimize the risks.

According to a recent AAA Foundation study, many drivers who understood the risks of drowsy driving admitted they had, nonetheless, driven while fatigued. Specifically, the AAA survey found that 96 percent of drivers see drowsy driving as a serious threat and a completely unacceptable behavior; however, among that same group, 3 in 10 admitted to driving when they were so tired that they had a hard time keeping their eyes open.

Lack of sleep slows reaction time and makes drivers more susceptible to forgetting or overlooking important tasks. A few seconds is all it takes to drift out of the lane or to miss a stopped vehicle on the road ahead. Individuals can take steps to help avoid the risks by making sleep a priority and avoiding driving late at night and early in the morning.

For more information, visit www.ntsb.gov/safety/safety-alerts/Documents/SA_061.pdf.

NTSB

Pennsylvania Launches PennDOT Connects

Recognizing transportation's role in connecting communities and supporting economic development, Pennsylvania Department of Transportation (PennDOT) Secretary Leslie S. Richards recently announced PennDOT Connects, an approach to enhance local engagement and improve transportation project planning, design, and delivery.

The new approach expands the department's requirements for engaging local and planning partners by requiring collaboration with stakeholders before developing project scopes. PennDOT Connects aims to transform development of capital and maintenance projects by ensuring that community collaboration happens early, and that planners consider each project in a holistic way to identify opportunities to improve safety, mobility, access, and environmental outcomes for all modes and local contexts. Earlier collaboration will ensure that projects meet current and projected needs as much as possible, and reduce costly changes later in the project development process.

The department is implementing PennDOT Connects requirements for collaboration on new projects in the State's 2017–2020 Transportation Improvement Program that meet certain criteria, such as those without previously defined project phases. This includes roughly 280 projects worth $2 billion.

To complement this ongoing collaboration, PennDOT is incorporating the policy into its applicable manuals and program processes and is developing training for staff in metropolitan and regional planning organizations.

PennDOT

NHTSA Teams with Adam Savage To Test Safety Technologies

In 2015, approximately 1 person died in a motor vehicle crash every 15 minutes. That statistic underscores the need for game-changing technology that can help save lives.

NHTSA

In a series of short videos for NHTSA, educator and television personality Adam Savage demonstrates vehicle safety technologies, such as blind spot detection, as shown here.

Research by the National Highway Traffic Safety Administration shows that 94 percent of all crashes are tied to human error, which means these deaths are highly preventable. To help save lives, NHTSA promotes new vehicle technologies that have the potential to prevent or reduce the severity of crashes. People can purchase these technologies in many new cars today—but only if they know about them.

To help spread the word about life-saving vehicle technologies, NHTSA teamed up with self-described science and technology champion Adam Savage to test and explain the value of five safety technologies in a series of short videos. Now with Tested.com, Savage was part of the original duo who created and fronted Discovery Channel's *MythBusters*, a television show to educate and entertain viewers by testing the validity of rumors and myths.

The NHTSA videos demonstrate automatic emergency braking, blind spot detection technology, forward collision warning, lane keeping support, and pedestrian automatic emergency braking. Savage puts each of these technologies through his special brand of testing and explains how each can help protect road users.

For more information, visit www.nhtsa.gov/equipment/safety-technologies.

NHTSA

Providing Pathways to Health Equity

The National Academies of Sciences, Engineering, and Medicine recently released a report that seeks to delineate the causes of and the solutions to health inequities in the United States. The report, *Communities in Action: Pathways to Health Equity*, focuses on what communities can do to promote health equity, what actions the many and varied stakeholders need to take, and the root causes and structural barriers that need to be overcome.

In the United States, some populations suffer from far greater disparities in health than others. Those disparities are caused not only by fundamental differences in health status across segments of the population, but also because of inequities in factors that affect health status.

Only part of an individual's health status depends on behavior and choice. Communitywide problems like poverty, unemployment, poor education, inadequate housing, and poor public transportation also contribute to health inequities, as well as the historic and ongoing interplay of structures, policies, and norms that shape lives. Social policies can mitigate these inequities and shape health in powerful ways.

The report offers objective analysis and advice to solve complex problems and inform public policy decisions.

For more information, visit www.nap.edu/catalog/24624/communities-in-action-pathways-to-health-equity.

The National Academies of Sciences, Engineering, and Medicine

Monitoring Bicycles and Pedestrians in Minnesota

In 2011, the Minnesota Department of Transportation (MnDOT) launched the Minnesota Bicycle and Pedestrian Counting Initiative, a statewide, collaborative effort to encourage and support the monitoring of nonmotorized traffic. MnDOT recently released a report summarizing the work of the department and the University of Minnesota between 2014 and 2016 to institutionalize bicycle and pedestrian monitoring.

The project team established a new statewide network with 25 permanent observation locations and a new district-based loan program for portable counting equipment. Other key accomplishments include a new MnDOT Web site for reporting annual and short-duration counts and a *Bicycle and Pedestrian Data Collection Manual* that local jurisdictions and consultants can use to design automated and manual programs to monitor nonmotorized traffic. The project team also established new annual training programs and called for creation of performance measures based on bicycle and pedestrian traffic counts.

Michael McCarthy, University of Minnesota

Minnesota is working to institutionalize pedestrian and bicycle monitoring throughout the State.

MnDOT and several local agencies now have plans and procedures in place to monitor bicycle and pedestrian travel in select jurisdictions and will share progress and innovations in their monitoring efforts.

For more information, visit www.dot.state.mn.us/research/reports/2017/201702.pdf.

MnDOT

Internet Watch

by Jon Obenberger

Transportation Data at Your Fingertips

Question: How do you develop and deploy a fully connected transportation system that makes the most of multimodal, transformational applications? Answer: By supporting it with a robust, underlying technological platform for collecting and sharing data. To meet the need for accommodating the enriched data from the connected vehicle environment, the Intelligent Transportation Systems (ITS) Joint Program Office of the U.S. Department of Transportation launched the Research Data Exchange (RDE) in 2013. Version 3.0 debuted in October 2016.

"The goal was to create a Web-based data resource to collect, manage, and provide access to archived and real-time multisource and multimodal data to support the development and testing of ITS applications," says Walter During, a transportation specialist at the Federal Highway Administration.

The objectives of the RDE are to enable systematic data capture from connected vehicles, mobile devices, and infrastructure and to integrate data from multiple sources into data environments that can be used by multiple applications for transportation management and performance measurement. The RDE also will support performing data quality checks and provide clean, well-documented data relevant to research.

Designed for Ease of Use

The RDE hosts a number of large, comprehensive data environments that can assist researchers in a number of transportation-related fields, including roadway safety, operations, and road weather information. The RDE offers users the ability to search by data type, facility, frequency, location, and data tags. Included in these search criteria are the start and end dates of the data collected. For example, a user can find data from a certain time and at a certain location (such as information related to a weather event). Datasets also are searchable with a map feature.

The exchange enables large downloads of multiple datasets at once. Rather than clicking each data element and downloading it individually from the site, a user places items in a cart for "checkout" (everything is always free of cost), and the system emails the items all in one zipped file.

Standard metadata documentation is included within every data environment on the RDE. This includes an explanation of the data collection, the file structure for the dataset, and definitions for each variable. The RDE team also developed a list of frequently asked questions, and users can ask for help directly from the specific data environment pages and an RDE expert will respond.

RDE Data Environments

The ITS Joint Program Office performs checks to ensure that the data accessible through the exchange are quality, well-documented, and available to the public at no cost. Collections of datasets from the same location and time period are called data environments, enabling users to search data by location or type. The RDE currently has 27 data environments, such as Intelligent Network Flow Optimization (INFLO), which contains four sets of data generated from a small-scale demonstration in 2015 along a 7-mile (11-kilometer) corridor of I–5 south of downtown Seattle, WA. New data environments are uploaded monthly.

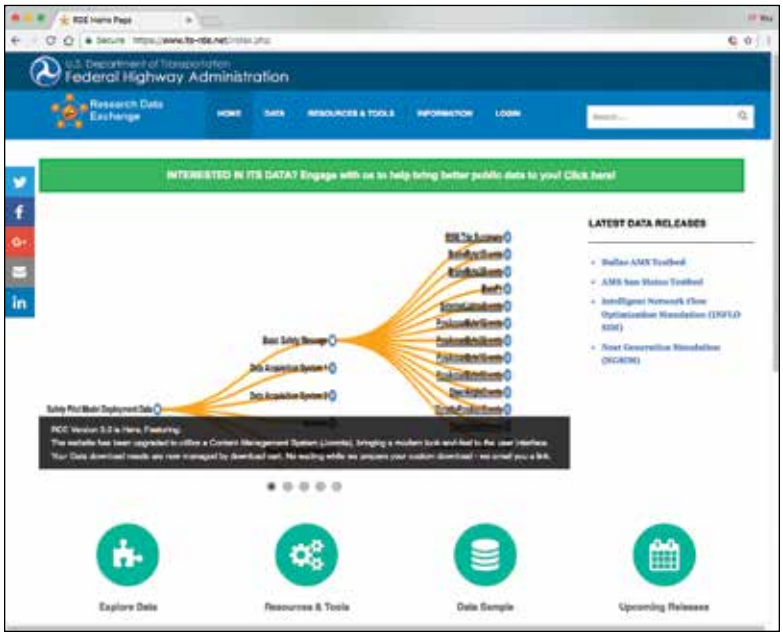
"A sample data file is available for each data environment," says Ariel Gold, a program manager with the ITS Joint Program Office, "so users can learn more about the data before downloading the entire dataset, which is especially useful for larger files."

The RDE provides access to connected vehicle- and passenger-related data involving private and transit vehicles, maintenance vehicles, probe vehicles, traffic monitoring and reporting devices, incident detection systems, traffic signals, weather, and other types of ITS sensors. This data sharing capability supports the needs of ITS researchers and developers, while reducing costs and encouraging innovation. Currently, the RDE has more than 1,000 registered users, of which 41 percent are from universities and 40 percent are from private industries.

"Researchers looking for high-quality surface transportation data should make the RDE their first stop," says Gold.

For more information, visit the RDE Web site at www.its-rde.net, or contact Ariel Gold at ariel.gold@dot.gov.

Jon Obenberger, Ph.D., P.E., is a senior transportation research engineer in FHWA's Office of Operations Research and Development.



Training Update

NATIONAL HIGHWAY INSTITUTE

by Judy Francis

Providing Comprehensive Training in LRFD

Since October 2007, the Federal Highway Administration has required all new bridges on Federal-aid projects to use load and resistance factor design (LRFD). LRFD is a probability-based design method in bridge engineering that aims to provide a uniform level of safety for all span lengths and material types.

The National Highway Institute (NHI) recently launched a series of three Web-based courses to help meet the training needs of structural engineers, designers, and project managers. These new trainings address design considerations for bridges according to the American Association of State Highway and Transportation Officials' *LRFD Bridge Design Specifications*. The series is a followup to NHI's popular instructor-led course launched in late 2016, LFRD for Highway Superstructures. Here's a peek at the new courses.

Special Topics in LRFD

The series begins with LRFD Design of Common Bridge Elements: Decks and Bearings, course number 130081C. This course provides a summary of general deck design procedures, including an introduction to different types of bridge bearings. Participants also learn steps for the design of elastomeric bearings and high-load multirotational bearings.

The second training, LRFD Steel I-Girder Details Design, course number 130081D, teaches participants to apply key LRFD limit state verifications for specific details associated with steel girders. A limit state is a condition of a structure beyond which it no longer fulfills the relevant design criteria. This course describes LRFD requirements for stiffeners, shear connectors, cross-frames, diaphragms, welded connections, and bolted field splices.

Prestressed Concrete Girder Topics, course number 130081E, is the final training in the series. The course describes prestressed concrete bridge materials and prestressing losses, along with design considerations for prestressed girders made continuous.

These Web-based trainings take a total of 8 hours to complete. NHI recommends them for structural and bridge engineers in the private and public sectors with up to 20 years of experience. At a minimum, participants should hold a bachelor of science in civil engineering or equivalent degree. Each course in the series costs $25 per participant. Participants are not required to take all three courses, but NHI recommends completing the series for a stronger foundational understanding of LRFD.

LRFD for Superstructures

The new series complements NHI's LRFD for Highway Bridge Superstructures, course number 130081, which has been updated from instructor-led to a mixed-delivery format and follows AASHTO LRFD specifications. The course combines instructor-led discussions with Web-based material and workshop exercises to describe LRFD for steel and concrete highway bridge structures, using extensive student exercises and sample problems to demonstrate overall design, detailing, and construction principles. As an alternative to the full 4-day course, NHI offers two individual 2-day courses: 130081A, a version of the course focusing only on steel structures, and 130081B, a version on concrete superstructures.

Michael Baker International

Construction of this bridge in Rankin County, MS, includes two bridge span sections, one using steel plate girders (at left) and the other using prestressed concrete beams. NHI's LRFD courses cover the fundamentals of design for both of these common bridge types.

Courses 130081, 130081A, and 130081B all require participants to complete a no-cost prerequisite, General Superstructure Design Considerations, course number 130081P. The Web-based prerequisite provides training on the fundamentals of designing LRFD highway superstructures, including a basic understanding of LRFD development and implementation, general design and location features related to superstructure design, and the primary loads and load combinations used for superstructure design.

"This new mixed-delivery approach provides a superior learning experience for participants, making the instructor-led training more effective," says Brian Kozy, the team leader for the Structural Engineering Team in FHWA's Office of Bridges and Structures. "Code [or governing specifications] application is taught via Web-based training so that participants may work at the pace appropriate for their experience level. [Having participants complete] the Web-based course before entering the classroom allows the instructors to spend more time interacting with participants, explaining behaviors and assumptions so they better understand the basis of the code."

For more information, visit www.nhi.fhwa.dot.gov. To register for a session or to sign up to receive alerts when sessions are scheduled, please visit the individual course description page.

Judy Francis is a contracted marketing analyst for NHI.

Communication Product Updates

Compiled by Lisa A. Shuler 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 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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Requests for items available from the R&T Product Distribution Center should be addressed to:

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For more information on R&T communications products available from FHWA, visit FHWA's Web site at www.fhwa.dot.gov, the FHWA Research Library at www.fhwa.dot.gov/research/library (or email fhwalibrary@dot.gov), or the National Transportation Library at ntl.bts.gov (or email library@dot.gov).

State of the Practice on Data Access, Sharing, and Integration (Report)
Publication Number: FHWA-HRT-15-072

Transportation planning and investment decisions rely on an accurate and thorough understanding of system performance, which requires integrating data from multiple sources. FHWA initiated the Virtual Data Access Framework to establish a prototype for State and local transportation agencies to share data on planning and operations from multiple sources within a region. The framework brings together many types of transportation data to give planners and operators a multifaceted view of transportation performance both over time and by location.

This state-of-the-practice review aims to lay both the technical and institutional foundation for all aspects of the framework. The review focuses on current data-sharing and integration practices among State and local agencies and provides examples of data environments, technical integration formats, and business rules for integration and sharing. Researchers investigated and documented best practices, applicability to the data-sharing framework, and incorporation of functional requirements for existing systems. They also examined success factors and data gaps.

This review, which will help in selecting the proposed pilot areas for the proof-of-concept tests of the Virtual Data Access Framework, also establishes a basis from previous experiences that FHWA and its partners will use in defining how the framework is designed in terms of data integration and sharing.

This document is available to download at www.fhwa.dot.gov/publications/research/operations/15072/index.cfm.

Cooperative Adaptive Cruise Control Human Factors Study: Experiment 1—Workload, Distraction, Arousal, and Trust (Report)
Publication Number: FHWA-HRT-16-056

Cooperative adaptive cruise control (CACC) is an automated vehicle application that aims to complement the vehicle operator's capabilities without degrading alertness or attention. Researchers at FHWA recently set out to answer a series of questions related to use of this technology.

Can CACC reduce the driver's workload relative to manual gap control (that is, maintaining the distance between a vehicle and the one in front of it)? Can CACC increase the probability of driver distraction relative to manual gap control? Can CACC result in reduced driver arousal relative to manual gap control? Does CACC increase the driver's ability to avoid a crash when exposed to an extreme braking event? And, do drivers trust the CACC system?

This report presents experimental results of a human factors examination of the effects of CACC on driver performance in a variety of situations. Researchers conducted the experiment using a driving simulator, placing subject drivers into scenarios in which they were embedded in platoons of CACC-equipped vehicles.

A total of 49 licensed drivers were tested in FHWA's Highway Driving Simulator, with 12 or 13 participants in each of 4 groups. All of the groups drove in the third position in a five-vehicle platoon in which all of the other vehicles were equipped with simulated CACC. The groups differed as to whether the participant vehicle was equipped with CACC and the type of event at the end of the drive that disturbed the longitudinal spacing of the platoon.

As assessed by the National Aeronautics and Space Administration Task Load Index, the CACC system did reduce perceived driver workload relative to driving without cruise control. CACC users appeared slightly more likely to engage in diversionary activities (for example, listening to the car radio) than control group drivers. CACC yielded a substantial and statistically reliable reduction in the probability of a crash. No evidence suggested that use of CACC leads to lower levels of driver arousal than manual gap control. Further, the study revealed that participants showed a great deal of trust in the CACC system.

This document is available to download at www.fhwa.dot.gov/publications/research/safety/16056/index.cfm.

Intersection Conflict Warning System Human Factors: Final Report (Report)
Publication Number: FHWA-HRT-16-061

Intersection conflict warning systems alert drivers on the through road of the presence of traffic at stop-controlled cross streets. The systems also warn drivers at stop-controlled approaches of the presence of traffic on the through lanes. Studies have shown these warning signs to reduce crashes at rural two-way stop-controlled intersections. However, no standard exists for the wording of warning messages or for the placement of these signs on the stop-controlled approaches.

FHWA performed this study to provide empirical evidence to support standardization of messaging and sign placement for conflict warnings at intersections. Researchers obtained data from 189 licensed drivers in a four-part laboratory study. In part one, participants viewed video animations of approaches with warning signs, and researchers assessed their comprehension of the signs. In part two, participants indicated their level of agreement with 21 statements concerning various aspects of the warning messages. Researchers used these ratings to assess participants' mental model for processing the conflict warning messaging. Researchers also identified three dimensions of this model. From most to least influential, these dimensions were comprehension, safety, and affinity or likeability.

In part three, participants rated the wording of messaging alternatives. Part four explored how comprehension varied between the time when the warning beacons were active and inactive, when the "WHEN FLASHING" placard was present or absent, and whether blankout signs improved comprehension over static signs.

This document is available to download at www.fhwa.dot.gov/publications/research/safety/16061/index.cfm.

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