Public Roads

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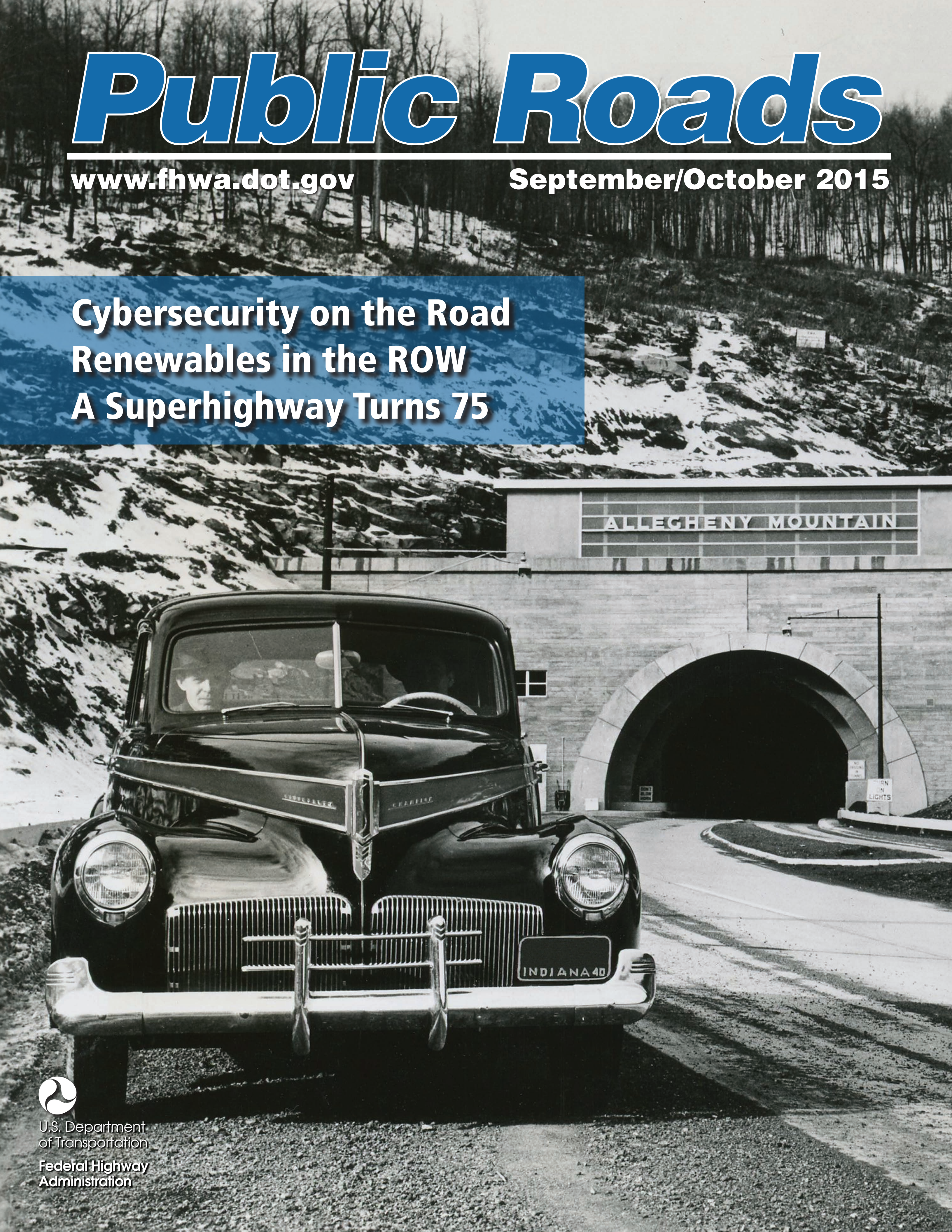
September/October 2015

Cybersecurity on the Road

Renewables in the ROW

A Superhighway Turns 75



U.S. Department of Transportation

Federal Highway Administration

Public Roads

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

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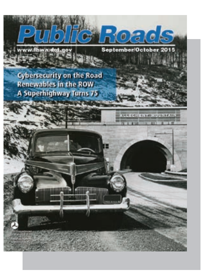

Front cover—In the 1930s, during the Great Depression, the Pennsylvania Turnpike Commission kept costs down by completing six tunnels that had been abandoned when the South Pennsylvania Railroad stopped construction in 1885. This tunnel through Allegheny Mountain, however, had to be built at a new location because the old railroad tunnel was unstable. For more on the turnpike's history, see "The Pennsylvania Turnpike Turns 75" on page 22 in this issue of PUBLIC ROADS. *Photo courtesy of Pennsylvania Turnpike Commission*.

Back cover—The smile on this boy's face as he peers through the rear window of a 1940 Chevrolet embodies the wonder that travelers felt 75 years ago driving the brand-new Pennsylvania Turnpike. His family's car is exiting the turnpike's original western terminus at Irwin, with the ramps to U.S. 30 and Pittsburgh in the background. For more on the roadway's history, see "The Pennsylvania Turnpike Turns 75" on page 22 in this issue of PUBLIC ROADS. *Photo courtesy of Pennsylvania Turnpike Commission*.

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Guest Editorial

Advancements in Transportation Training

As the training arm of the Federal Highway Administration, the National Highway Institute has a long history of innovation in delivering training to transportation professionals. Improving the condition and safety of the Nation's roads and bridges means building on the skills of professionals to enhance their job performance. NHI ensures that its constituents receive high-quality training by staying on top of the latest digital tools, adult learning research, and industry advancements.

But how do you remain innovative after 45 years? By developing forward-thinking solutions that maximize flexibility under time, budget, and travel constraints.

In 2014, NHI trained more than 13,000 participants in instructor-led sessions across all 50 States. Each session, whether delivered in person or by video conference, was led by experienced practitioners who are national experts in their fields and qualified through NHI's Instructor Certification Program.

Staying innovative means finding new ways to reach broader audiences. That is why NHI offers more than 150 Web-based trainings available 24/7. Another 11 Web-conference trainings enable participants to connect with each other and course instructors virtually, without the time and expense required to travel to in-person training. In fiscal year 2014, NHI received more than 27,000 registrations for Web-based and Web-conference training.

Earlier this year, NHI rolled out its latest innovation in delivery of training: an event that enabled transportation professionals to participate in training in a virtual world environment without leaving their desks. During the International Foundations Congress and Equipment Expo in March, NHI piloted a virtual world platform. Participants used avatars (virtual representations of themselves) to visit a virtual trade fair showcasing geotechnical equipment, to talk with each other and industry experts, and to participate in technical sessions and lectures as if they were onsite. Learn more about this event in "Making Virtual a Reality" on page 14 in this issue of PUBLIC ROADS.

Virtual technology also plays a role in the instructor-led course 130055 Safety Inspection of In-Service Bridges, in which inspectors assess two virtual bridges, a four-span steel bridge over a divided highway and a single-span concrete structure over water. NHI is also developing two additional virtual bridges. The virtual inspections provide an opportunity for participants to identify a comprehensive list of defects unlikely to be encountered on any one real-world bridge. For more information on this course, see the Training Update article "Bridge Inspection Goes Virtual" in the May/June 2013 issue of PUBLIC ROADS.

In addition, NHI and the FHWA Office of Operations are using another innovative method for training with the Operations discipline. Participants use a "flipped classroom" approach in which they complete foundational learning online before meeting virtually during a Web conference for discussion and problem-solving. This approach makes it easier for participants to seek guidance after they have all the information, rather than using up valuable instructional time in a lecture.

Just as innovation is critical for building, maintaining, and operating a first-class transportation system, adopting new training techniques helps ensure that the latest knowledge gets into the hands of those who need it. Embracing these latest capabilities, we look forward to training transportation professionals for the next 45 years and beyond.

Valerie Briggs
Director
National Highway Institute

Taming Cyber Risks

Advances in technology and connectivity are challenging the transportation community to improve cybersecurity.

by Edward Fok, Ray Murphy, Ekaraj Phomsavath, and Jonathan Walker

Photo: Shutterstock, Dabarti CGI.

Transportation systems for highways and arterials have advanced from a collection of independently operating devices to highly interconnected, far-reaching, and integrated systems. In congested urban environments, highly integrated and dynamic controls of the highway and arterial systems are required to provide basic and safe mobility services. These integrated systems require a reliable communications network that may span a broad geographical region.

The elements of these complex control systems have been designed for safety, ease of maintenance, and reliability. For example, the conflict monitor—which is found in all traffic signal controllers—is, in its most basic form, a simple analog electrical circuit designed to immediately turn all signal lights to flashing red when it detects electrical currents that could simultaneously energize conflicting green lights. Most control systems were not designed, however, to operate in the adversarial environment (with potential security threats) now faced by highway agencies that are leveraging the benefits of modern communications technologies.

The Intelligent Transportation Society of America, in its report titled *Connected Vehicle Assessment: Cybersecurity and Dependable Transportation*, estimates that by 2020 there may be more than a billion machine-to-machine devices in transportation (such as those found in intelligent transportation systems and advanced transportation management systems), and more than half of those will be road vehicles.

Transportation systems are not only becoming more connected, but also more dependent on communications and information technologies. These technological advances improve the efficiency and functionality of transportation systems, but they also increase potential vulnerabilities to transportation safety. In response, transportation agencies across the country are rising to the challenge to learn more about cybersecurity issues and develop and implement solid cybersecurity programs.

Security Through Obscurity

Historically, public agencies relied on "security through obscurity" as the guiding principle for security. A system might be vulnerable, but operators thought that if these weaknesses were not known, then persons with malicious intent were unlikely to find them. Agencies believed that the secrecy surrounding design and use was sufficient protection.

Prior to the digital revolution, this approach worked well because no one paid much attention to communications systems on the low-performance networks used by highway agencies. However, beginning in the late 1990s, many public agencies began switching to common commercial technologies such as Wi-Fi and Ethernet for field devices (traffic signals, roadside sensors, and dynamic message signs, among others) to communicate with central monitoring systems. These technologies enable agencies to use inexpensive, readily available equipment that is easy to use and maintain. However, this equipment also reduces any value from reliance on security through obscurity because the technologies are well known.

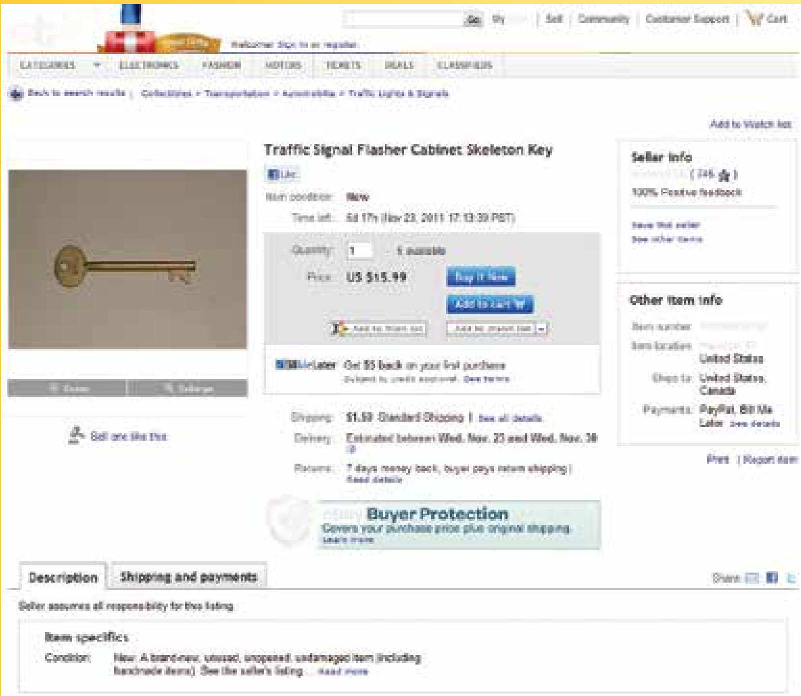
Hobbyists and car enthusiasts have shown interest in manipulating the transportation system for nearly 30 years. Today, some of these hobbyists are known as "hackers." In general, hackers exhibit a strong sense of curiosity and enjoy investigating systems for the sheer challenge of the task. Their curiosity is similar to a mountain climber's desire to be the first to overcome a challenge. An early example of this interest in the transportation realm occurred with the optical traffic signal priority system. Curious hackers reverse engineered these devices and published online the plans to build a vehicle emitter that could signal the infrastructure to change the traffic signal using components available in most electronics stores. Hackers' interest in the transportation system has continued today to include transit cards, smart parking meters, dynamic message signs, and many other transportation field systems.

In 1997, the Federal Highway Administration's Intelligent Transportation Systems Joint Program Office (now part of the Office of the Assistant Secretary for Research and Technology) produced *Intelligent Transportation Systems (ITS) Information Security Analysis* (FHWA-JPO-98-009). This report was an assessment of vulnerabilities in the early National ITS Architecture. However, the report was ahead of its time and did not receive widespread attention at the time of publication.

Risk in the 21st Century

FHWA's interest in cybersecurity risk to transportation systems was rekindled in the first decade of the 21st century. The renewed interest began when a State department of transportation requested from FHWA established guidelines to secure transportation communication networks. Until this request, the only known cyber incidents related to transportation were directed against portable dynamic message signs. Changing a dynamic message sign to read "Zombies Ahead"

A crew member with the Washington State DOT works on wiring a new traffic signal system in Kirkland, WA. Traffic signals are part of complex, interconnected transportation networks that can be susceptible to cyber attacks. *Photo: Washington State DOT.*



This screen capture shows a skeleton key for a traffic signal flasher cabinet for sale on a popular Internet site.

instead of "Slow Down, Work Zone Ahead," while embarrassing to the operating agency, does not pose an immediate threat to public safety. In fact, an argument could be made that the altered message may cause drivers to slow down more effectively than the original message.

The DOT's request prompted FHWA to take a closer look at the transportation system from the perspective of a cyber attacker. After identifying the most serious weaknesses, FHWA launched an awareness campaign to inform State and local DOTs about the importance of securing their transportation systems. FHWA's biggest challenge is to increase awareness in a way that reaches system operators without drawing attention to the vulnerability of the transportation system. The campaign began in 2011 with a webinar titled, "Who's Minding Your Data? An Introduction to Cyber Security Issues in Transportation." Additional and ongoing campaign efforts include consultations at Institute of Transportation Engineers' events, presentations at the Transportation Research Board's annual meetings, outreach to FHWA division offices, and various published articles and communications.

The transportation system is no longer immune to cyber-related risks, as evidenced by some recent security breaches. For example, vulnerabilities in the transportation system allowed hobbyists to unwittingly derail light rail trains.

Hackers have also exploited other vulnerabilities, from electronic toll tags to traffic signal controllers. In addition, hackers/activists, or "hacktivists," have taken advantage of system vulnerabilities to enhance the effectiveness of real-world protests through simultaneous cyber attacks. More specifically, hacktivists may launch cyber attacks by trying to shut down computer networks of targeted companies or industries in protest of actions they consider to be political or social injustices.

Transportation officials also seek to learn from the health care, financial services, and retail sectors that are facing a new breed of criminals who exploit identified vulnerabilities. Even though the vulnerabilities are shared openly, many asset owners fail to take the proper precautions and, therefore, their systems remain exposed to threats. A scan of the news in 2014 shows a number of major cybercrime incidents that took place because of failure to take action against known vulnerabilities. A prominent example was the cyber attack targeting one of the largest motion picture production and entertainment companies in the world. The cyber attack destroyed its systems, disrupted business operations, and compromised

Trevor Wrayton, Virginia DOT

Dynamic message signs, like this one on southbound I–95 in Virginia, provide drivers with valuable travel information. However, this technology has been a target for hackers across the country.

large quantities of proprietary information, as well as employees' personally identifiable information and confidential communications.

The New Normal

In 2009, the ITS Joint Program Office announced efforts to research vehicle-to-vehicle and vehicle-to-infrastructure communications for safety. Technologies developed from the research have the potential to improve highway safety and mobility significantly. However, by 2011 the hacker community had picked up on the potential vulnerabilities of such technology. At an annual hacker event called DEFCON, after a presentation about hacking a car's electronic control system, a presenter showed a news segment on the ITS Joint Program Office's announcement to an audience of approximately 400 hackers. One of the first questions asked from the audience was, "Can we write a virus to go from car to car?" With this question, it was clear that the hackers' interest was piqued.

This effectively ended the transportation system's happenstance security through obscurity.

The final indicators that cyber risk is "the new normal" for transportation management were three major transportation cyber incidents in 2014. One of the incidents, involving wireless sensor vulnerabilities, captured the attention of the media, but was not a serious threat to transportation systems. The other two events were significant enough for FHWA to assist the infrastructure owners with analysis and then issue cyber incident advisories to agency partners. The technologies involved included a traffic signal controller and fixed dynamic message signs.

As of April 2015, FHWA had issued three cyber incident advisories, including the two in 2014, and a third issued in April 2012. "The recent uptick in major cybersecurity incidents in the transportation sector is really an eye-opener," says Bob Arnold, director of transportation management with FHWA.

With trends continuing to move to more complex, networked transportation systems, transportation professionals must be aware of vulnerabilities and work to prepare the systems to mitigate risk as much as possible.

Here, participants are attending a presentation at DEFCON in 2014. The hacking conference has helped to identify vulnerabilities in transportation systems.

Cybersecurity Framework

In tandem with the uptick in cyber incidents, the Federal Government has developed a number of tools to help transportation agencies and infrastructure owners better protect their systems. One of these tools is a generic cybersecurity framework developed by the National Institute of Standards and Technology (NIST) at the U.S. Department of Commerce.

In February 2013, President Barack Obama issued an executive order, "Improving Critical Infrastructure Cybersecurity," to enhance the cybersecurity and resiliency of infrastructure critical to national economic and security interests. The executive order directed NIST to create a voluntary cybersecurity framework for agencies and organizations to use to develop the capabilities to identify vulnerabilities, and mitigate and respond to cyber threats.

A diverse group of stakeholders and security professionals contributed to development of the framework, which NIST released on February 12, 2014. The *Framework for Improving Critical Infrastructure Cybersecurity* is available at www.nist.gov/cyberframework.

The cybersecurity framework provides businesses, owners of critical infrastructure, and transportation agencies with an extensive set of tools to develop best practices and industry standards to improve resilience to malicious and incidental disruptions. The framework can help stakeholder organizations assess and improve existing cybersecurity programs, or create new programs. The framework uses a methodical approach for improving an organization's cybersecurity capability by identifying, assessing, and responding to risk. In addition, the tools help organizations better align their cybersecurity and resiliency program objectives with their strategic plans, identify priority areas for process improvement, and establish a plan to sustain and improve their cybersecurity programs.

The framework has three components: the core, framework profiles, and tiers. The core focuses on effectively managing cybersecurity risk and the ability to recover from an attack; in essence, it is the incidence response process. The framework profiles define the set of baseline activities an organization is currently using and the desired or target capabilities they would like to achieve. The tiers facilitate the gap analysis process, which leads to a tiered implementation for cybersecurity protection. The tiers provide a context for agencies to better understand their cybersecurity risk management practices and to rate them.

Using the cybersecurity framework, FHWA is creating a tool for State and local transportation agencies. The tool will be one part

When the ITS Joint Program Office announced efforts to research connected vehicle technology to improve roadway safety, it piqued the interest of the hacker community.

U.S. Department of Transportation

of the overall agency response to the emergent cyber resilience challenge. To develop the tool, FHWA will tailor the NIST framework for transportation agencies with help from industry and operating agencies. The tool, now in the early stages of planning, will include a structured cybersecurity assessment and development program for the transportation community of practice. Transportation agencies will be able to use the tailored framework as a self-assessment tool to evaluate their current practices and to identify where they can improve current cybersecurity activities and programs. The goal of the tool is to improve the overall protection and resilience of the Nation's highway infrastructure.

FHWA's Vision For Cybersecurity

Many infrastructure owners and operators already are challenged with operating and monitoring their transportation systems with limited resources, expertise, and funding. The new challenges in cybersecurity and resiliency impose additional demands on these resources. FHWA's Office of Operations is striving to assist owners and operators with proactive methods to improve resiliency in the transportation system.

The Office of Operations is working to establish a formal process of monitoring, alerting, and advising owners and operators of the national transportation infrastructure through a single entity. Other organizations and processes cover some aspects of monitoring, alerting, or advising industrial control systems or information technology deployments. However, no single entity currently exists to achieve the following objectives under one entity for transportation owners and operators: (1) monitoring cybersecurity incidents on transportation infrastructures; (2) alerting owners, operators, and manufacturers of transportation infrastructures about a security breech or vulnerability; (3) advising on post-incident responses; (4) investigating potential system vulnerabilities; and (5) providing education and awareness training and information.

Monitoring. The monitoring component will provide transportation owners and operators with a secure method of notifying a single entity regarding events, incidents, or vulnerabilities without exposing the suspected activities to the public. The two primary reasons for maintaining a secure method of communication are to ensure the confidentiality of the owner or operator and to avoid exposing unresolved vulnerabilities.

The established entity also will monitor alerts from other sources, such as the U.S. Department of Homeland Security's (DHS) Industrial Control Systems Cyber Emergency Response Team, which works to reduce risks across all critical infrastructure sectors. In addition, the entity will monitor the Center for Internet Security's Multi-State Information Sharing and Analysis Center, which focuses on networking cyber threat prevention, protection, response, and recovery for the Nation's State, local, tribal, and territorial governments.

Alerting. The alert component will concentrate on warning owners and operators, operating professionals, manufacturers, and FHWA division offices regarding transportation infrastructure vulnerabilities. The warning system will enable quick responses to ongoing investigations with initial remedial advice.

Advising. The advising component will bring together experts who can investigate the unresolved vulnerabilities through collaboration among the owner and operator, DHS and the Cyber Emergency Response Team, and the Multi-State Information Sharing and Analysis Center. The team of experts will develop specific advice and present the information to technical and nontechnical stakeholders.

Investigating. The investigation component will use a vulnerability assessment to identify, quantify, and prioritize the transportation infrastructure threat. Typically, an assessment is performed according to the following steps:

1. Cataloging assets and capabilities (resources) in a transportation system.
2. Assigning quantifiable value (or at least rank order) and importance to those resources.
3. Identifying the vulnerabilities or potential threats to each resource.
4. Mitigating or eliminating the most serious vulnerabilities for the most valuable resources.

Providing Education and Awareness. The education and awareness component will provide educational resources, as well as outreach and awareness, to owners, operators, and FHWA division offices on fundamental principles and best practices in cybersecurity for transportation systems. The transportation-focused tool that FHWA is creating based on the NIST framework will play a major role in education and improvement of awareness.

The tool will help to address the need to increase engagement across the Federal agencies, transportation communities, and private industries to support a common operating response to cyber attacks against critical transportation infrastructure. The education and awareness outreach component of the tool also will provide a platform for hosting forums that bring stakeholders together to share best practices in cybersecurity and their experiences with implementing the NIST cybersecurity framework. These functions will foster risk management and cybersecurity management communications among the internal and external transportation stakeholders.

Rising to the Challenge

Highly networked and connected infrastructure is a critical component of a modern highway transportation system. These systems can no longer rely on security through obscurity and maintaining a low profile, as they did historically. With today's hacker community revealing myriad vulnerabilities in transportation systems, any pretense to the effectiveness of this old approach to security has evaporated. Transportation leaders and infrastructure owners and operators now understand the importance of protecting their systems from potential cyber risks.

FHWA, in collaboration with its institutional partners, has taken several initial steps to improve the cyber resiliency of transportation systems. The agency's customization of a tool based on the NIST cybersecurity framework will help operating agencies respond to today's cyber resiliency challenge. In addition, FHWA's development of a formal process for monitoring and communicating cybersecurity issues through a single entity will improve the speed of response to incidents on a national scale.

"The transportation industry has a lot of ground to make up to address the current cybersecurity and resiliency challenges," says Grant Zammit, operations technical service team leader with the FHWA Resource Center. "But we've benefitted from the hard lessons learned by other industries, which is helping to guide our field of practice to develop capabilities and rise to the challenge."

The current cybersecurity challenges are just the beginning. Connectivity in the transportation system will increase to include new devices, operational partners, and connected services never imagined by the original designers of these systems. Connected vehicle technology is just one example of an increasingly connected future in transportation. Although the operational benefits of these technologies and services are significant, they will test the resilience of existing and planned systems.

FHWA and State and local agencies can best address these long-term challenges by making cybersecurity and resiliency an essential component of their operations and maintenance.

"This is the new reality that the transportation community is facing, and there is no magic bullet," says Dennis Motiani, executive director of the National Operations Center of Excellence. "But it is our job to use the knowledge we have about our systems and the tools we are building to make the job of a hacker significantly more difficult."

This article is a collaborative effort of the voluntary members of FHWA's Transportation Cybersecurity working group within the Office of Operations.

Edward Fok is a transportation technologies specialist at FHWA's Resource Center. Fok is experienced in many facets of advanced transportation systems for both metropolitan and Federal governments. One of his current roles is FHWA's lead on tackling transportation cyber resiliency challenges. He holds an M.S. in electrical engineering and a B.S. in mechanical engineering, and he is a licensed electrical engineer and transportation engineer.

Ray Murphy is an ITS specialist with more than 30 years in the transportation industry. As a member of FHWA's Operations Team in the Resource Center, Murphy provides support for real-time data systems, cybersecurity, and road weather operations. Previously, he was an ITS project manager and field engineer with the Illinois Department of Transportation. Murphy served as an officer in the U.S. Navy Civil Engineers Corps and he holds a B.S. in electrical engineering from the Illinois Institute of Technology.

Ekaraj Phomsavath is an ITS engineer and currently oversees New Jersey's transportation operations programs in the FHWA New Jersey Division Office. He has worked for FHWA for 10 years. Phomsavath's primary responsibilities include ITS deployments, traffic incident management, traveler information, work zones, and national ITS initiatives. Phomsavath has a B.S. in computer science from the University of the District of Columbia.

Jonathan Walker has a major responsibility with the oversight of vehicle-to-infrastructure deployment on a national level with the FHWA Office of Transportation Management. Walker received an M.S. in engineering from Johns Hopkins University and a B.S. in electrical engineering from Howard University. He served 4 years in the U.S. Marine Corps as an electro-mechanical technician and is a licensed professional engineer in the District of Columbia, Maryland, and Virginia.

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AN ARRAY OF Possibilities

by Gina Filosa and Carson Poe

A growing number of highway projects are greening rights-of-way with solar power and other renewable sources of energy.

(Above) The Michigan DOT installed two solar-powered carports at a parking lot at the interchange of State Route 44 and I–96 in Grand Rapids, MI. Electricity generated by the array powers the lighting at the interchange. *Photo: Michigan DOT Photo Lab.*

Significant sections of the Nation's surface transportation system are at risk due to changes in the Earth's climate. The effects of climate change, such as more frequent and intense heat waves and flooding, are already causing impacts on the Nation's transportation infrastructure. State Route 37 near San Francisco Bay, for example, is at risk of flooding due to rising sea levels, according to the California Department of Transportation. In another western example, roads in Fresno, CA, are wearing more quickly due to the increasing duration of heat waves and the high temperatures they produce. On the east coast, catastrophic flash flooding associated with Tropical Storm Irene in 2011 resulted in significant damage to transportation infrastructure: Erosion destroyed roads and rail beds, undermined bridge foundations, and washed out culverts.

Transportation agencies are working to balance vulnerabilities and risks, and to identify strategies to adapt infrastructure to the effects of climate change. To this end, the National Research Council of the National Academies' *Special Report 290: Potential Impacts of Climate Change on U.S. Transportation* describes the nature of the potential impacts and suggests appropriate adaptation strategies and organizational responses.

Unfortunately, the costs associated with adaptation strategies strain transportation budgets that are already tight. Funding for the Nation's surface transportation system has declined over the last decade, and State transportation agencies are increasingly challenged by the shortfall in resources from traditional funding sources, such as from motor fuel and highway use taxes. In *Intergovernmental Challenges in Surface Transportation Funding*, the Pew Charitable Trusts reported that between 2002 and 2011, surface transportation funding fell by $27 billion, or 12 percent. In addition, both the Highway Account and the Mass Transit Account of the Highway Trust Fund are nearing insolvency. In light of shrinking budgets, transportation agencies are seeking ways to reduce costs and generate revenue.

Reducing greenhouse gases can help mitigate climate change. To help reduce greenhouse gas emissions within the confines of tight budgets, some State transportation agencies are using highway rights-of-way (ROW) to install renewable energy technology, such as wind turbines and solar panels, to generate electricity and supply it to utility companies. Depending on the site, ample highway ROW—including land alongside the highways, in the medians, within interchanges, and beyond the clear zones—can be ideal for such technology if it is consistent with the continued use, operations, maintenance, and safety of the highway facility, and will not impair the highway or interfere with the free and safe flow of traffic.

In addition to the environmental benefits of using clean, renewable sources of electricity, departments of transportation also stand to gain by lowering energy costs and creating new revenue streams. In some cases, the developer or utility installs the technology and then pays rent to the State for use of the land. The DOT also can form agreements with utilities to purchase the electricity generated by the technology at favorable rates over long periods. Those purchases can help offset the costs of purchasing electricity to provide lighting for other segments of the transportation infrastructure.

A New Light for Rights-of-Way

International transportation agencies have long installed renewable energy technologies within highway ROW. Since the 1980s France, Germany, the Netherlands, Switzerland, and the United Kingdom have all installed various types of solar arrays along highways. But the practice has only recently caught hold in the United States. Prior to 1988, the Federal Highway Administration prohibited the installation of utilities within interstate ROW, and many States adopted the same policy for State highways. This prohibition was consistent with the American Association of State Highway and Transportation Officials' policies for longitudinal accommodation. In 1988, the FHWA policy changed to allow each State to decide whether to permit utilities within interstate ROW and to specify the conditions for approval, or to continue to adhere to the stricter AASHTO policies.

The 1988 FHWA policy also stated that public utilities (that is, utility service available for public use) that were "in the public interest" could be allowed in interstate ROW under a DOT's approved utility accommodation policy. The conditions are that the utility service needs to be accommodated in ways that are safe for the traveling public and do not interfere with the operation of the highway.

The development of renewable energy technologies and alternative fuel facilities since then, and of opportunities to place these facilities within highway ROW, has caused FHWA and the States to reexamine the existing definition of "utility." Some States do not view, or have not made a decision about, renewable energy installations as utilities, which is part of the reason why the practice has not been adopted more widely.

In 2008, the Oregon DOT became the first agency in the United States to install a solar panel array along a highway ROW. (See "Spotlight on Solar Arrays" in the November/December 2012 issue of PUBLIC ROADS.) For its solar highway demonstration project, Oregon DOT installed 594 ground-mounted solar panels at the interchange of I–5 and I–205 in Tualatin, in the southern Portland metropolitan area. The panels produce approximately 130,000 kilowatt-hours of electricity annually—about one-third of the amount needed to illuminate the interchange.

"The project has been highly visible," says Oregon DOT program manager Allison Hamilton. "We expect approximately 1.6 billion motorists to drive by the panels over the structures' lifetime."

Following the success of Oregon's project, several other State transportation agencies began considering similar projects. The Ohio DOT partnered with the University of Toledo to install a large array of solar panels north

Solar panels, erected onsite in Tualatin, OR, stand in front of an easel holding a preliminary visualization of Oregon DOT's solar demonstration project. *Photo: Gary Weber, Oregon DOT.*

Seen here in an aerial photo in front of a row of trees (left center), Oregon DOT's solar array in Tualatin is located on a triangular parcel of land between two interstate highways and an exit ramp. *Photo: Gary Weber, Oregon DOT.*

Solar Array Projects Along U.S. Highways*

Placed in Service	State	Project
December 2008	Oregon	I–5/I–205 Solar Demonstration Project
January 2011	Ohio	Veterans' Glass City Skyway Solar Demonstration
February 2012	Colorado	E-470 Toll Road Solar Arrays
October 2012	Massachusetts	State Route 44 Solar Array
December 2012	Massachusetts	MassDOT District 2 Solar Array
July 2015	Massachusetts	Framingham I–90 Interchange 13 N Framingham I–90 Interchange 13 S Framingham I–90 Westbound Service Plaza Natick I–90 Westbound Embankment
Planned	Massachusetts	Plymouth Route 3 Exit 5 Salisbury, District 4 Depot Stockbridge I–90 at Interlacken East 1 Stockbridge I–90 at Interlacken East 2 Stockbridge I–90 at Interlacken West West Stockbridge I–90 Exit 1

**Excludes renewable energy projects located at highway ROW not directly alongside the roadway, such as at rest areas or carports.*

of the Veterans' Glass City Skyway bridge next to I–280 in Toledo, OH. The agency wanted to generate electricity to offset the bridge's lighting consumption, as well as promote the use of solar energy in the State. The array installation began operation in January 2011. Despite this and a handful of other installations across the country, renewable energy facilities in highway ROW were at that time still considered fairly uncharted territory in the United States.

When these initial projects were just getting underway, the regulations that governed the use and management of highway ROW did not address renewable energy facilities, which present special challenges. Depending on the location, statutory or regulatory constraints or environmental, economic, or political variables may limit opportunities for developing renewable resources. For example, a State's utility rules for net metering—a billing mechanism that credits customers who add electricity to the grid—may limit the amount of energy that a given site can generate. Finding an area that can support renewable energy facilities and is not otherwise being used or designated for future use also can be challenging. For example, long-range transportation plans may present potential siting conflicts, or other incompatibilities could arise such as wind project sites that might interfere with airport activities.

FHWA anticipated that State transportation agencies interested in Oregon DOT's efforts might have questions about using renewable technologies. Dave Leighow, a realty specialist with FHWA's Office of Real Estate Services, recalls internal conversations around that time: "We decided to consider the experience of Oregon DOT as an opportunity to take a broader look at the regulatory landscape related to renewable energy and highway ROW."

In 2009, FHWA issued a memorandum titled "Guidance on Utilization of Highway Right-of-Way," which clarifies how highway ROW can be used for renewable energy facilities. The guidance details when a State transportation agency can accommodate renewable energy facilities under its approved utility accommodation policy and when it would require an airspace lease (that is, a lease to cover highway air rights, which describe the area above or below the transportation facility and located within its ROW boundaries). Non-highway use of interstate ROW is subject to airspace leasing requirements, which involve charging current fair market value or rent for use of the ROW. This requirement may be waived if the agency shows that an exception is in the overall public interest for social, environmental, or economic purposes. This exception may be appropriate for activities that mitigate climate change or contribute to improvements in air quality.

A year later, FHWA sponsored a research effort to learn more from Oregon DOT and other State transportation agencies contemplating highway renewable energy projects. FHWA published the resulting report, *Alternative Uses of Highway Right-of-Way*, in January 2012. The report provides information to help State transportation agencies and local public agencies evaluate the feasibility of installing renewable energy technologies in ROW and identify effective practices for doing so. (*Editor's note:* The authors of this PUBLIC ROADS article wrote the report.)

The Trend Continues

At the time that FHWA published *Alternative Uses of Highway Right-of-Way*, two early adopters—Oregon DOT and Ohio DOT—had built solar energy projects within highway ROW, and the Texas DOT had constructed wind turbines at two rest areas. State transportation agencies in California, Colorado, and Massachusetts were actively developing projects or conducting feasibility studies to identify promising locations to implement a variety of renewable energy technologies. However, no other State transportation agency had pioneered the use of highway ROW for solar energy projects in the way that Oregon DOT was attempting.

In addition to its solar highway demonstration project, Oregon DOT constructed the Baldock Solar Station, a 1.75-megawatt solar array at the French Prairie Rest Area on I–5 in Clackamas County. The 6,994-panel array sits on about 7 acres (2.8 hectares) of Oregon DOT property on the east side of the northbound rest area. The Oregon DOT placed the solar power plant into service in January 2012, and it now produces approximately 1.97 million kilowatt-hours of clean, renewable energy annually.

Reflecting on the first years of Oregon DOT's two solar highway projects, Hamilton believes that the agency has found an approach that works. "Our agency essentially has the basics covered now," she says. "The initial excitement may have waned a bit, but the projects are working perfectly. They require very little maintenance and basically blend into the background, so to speak. They operate themselves."

She notes that although the weather obviously affects the panels' output during the winter months, overall output has exceeded initial estimates. And concepts that were at first largely unfamiliar to the agency, such as retrieving renewable energy tax credits, have now become more routine.

"The challenge I think DOTs may face as they consider highway renewable energy projects," Hamilton observes, "is finding utility partners willing to take on projects they may find unconventional or too small. The costs are coming down, but they may still be too high for some utilities."

The Oregon DOT developed its solar highway demonstration project through a partnership with Portland General Electric, which owns and operates the plant, and U.S. Bank as the utility's tax equity partner. The partnership makes use of State and Federal renewable energy tax credits and grants offered through Energy Trust of Oregon and the utility's Clean Wind Fund.

Solar energy produced by the array feeds into the grid during the day, in effect running the meter backwards for energy needed at night to light the interchange through a solar power purchase agreement with the utility. The success of the demonstration project led Oregon DOT and Portland General Electric to collaborate to build the larger Baldock Solar Station. Portland General Electric operates and maintains the Baldock array under a lease arrangement with Bank of America, which financed and owns the project. The return on these investments includes generating renewable, clean energy that goes into Portland General Electric's grid to serve its customers; creating new sustainable businesses and jobs; demonstrating innovative green technology; offering national leadership in sustainable development; and providing the State with an opportunity to gain revenue.

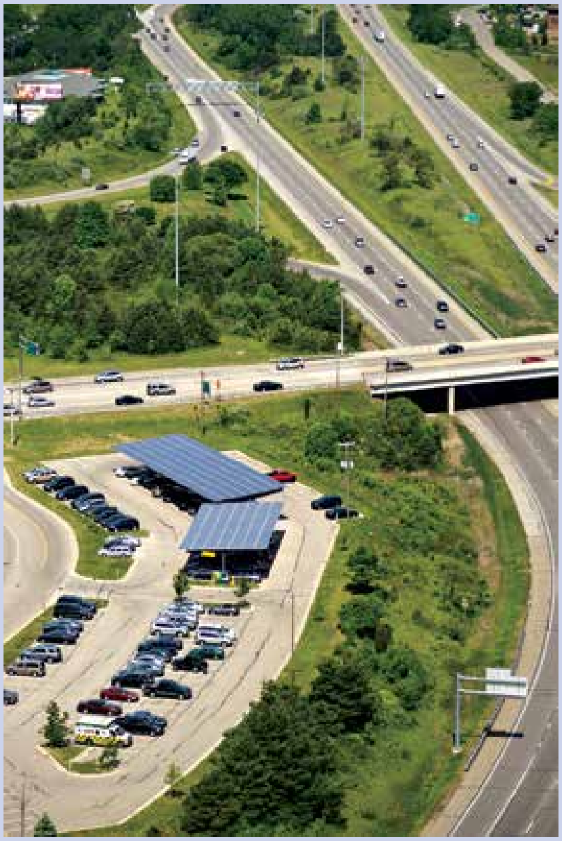
In the 3 years since FHWA published *Alternative Uses of Highway Right-of-Way*, State transportation industries have maintained their interest in solar electricity facilities within ROW. In addition to Oregon and Ohio, Colorado and Massachusetts have installed solar arrays along ROW. Texas and Florida have conducted research studies and geospatial analyses to assess highway renewable energy project options, and other States have issued requests for proposals or information regarding

Beyond Highway Clear Zones

State transportation agencies are considering not only the properties adjacent to highway clear zones for use in generating renewable energy, but also all of the ROW. At least seven State transportation agencies have constructed solar array or wind turbine installations at rest areas or carports flanking highways. Some agencies are also considering brownfields as sites for generating renewable energy. The U.S. Environmental Protection Agency has developed a *Liability Reference Guide for Siting Renewable Energy on Contaminated Properties* for stakeholders considering such projects.

Renewable Energy Projects at Highway Rest Areas and Carports

Placed in Service	State	Project	Type
September 2003	Texas	Two Rest Area Wind Turbine Projects	Wind
April 2009	Missouri	Conway Rest Area Wind Turbine	Wind
August 2010	Colorado	Parachute Rest Area Solar Flowers	Solar
January 2011	Arizona	Riverpoint Solar Research Park	Solar
April 2011	Connecticut	North Haven Service Plaza	Solar
January 2012	Oregon Connecticut Michigan	Baldock Solar Station Milford Service Plaza I–96/State Route 44 Solar Carport	Solar Solar Solar
March 2012	Michigan	Seney Rest Area 239 Saint Ignace Rest Area 241 Chelsea Rest Area 832 New Buffalo Welcome Center 707 Clare Welcome Center 634	Solar Solar Solar Solar Solar
Planned	Massachusetts	Highway Park & Ride Lots	Solar



Michigan DOT's solar carport project is shown here adjacent to a State Route 44 interchange of I–96. The project shades cars as it generates electricity. *Photo: Michigan DOT Photo Lab.*

The Massachusetts DOT placed this solar array alongside State Route 44 near Carver, putting the solar panels into service in October 2012. The 99-kilowatt system provides electricity to a nearby water treatment facility. *Photo: Gina Filosa, Volpe Center.*

the development of solar panel installations along highway ROW.

An Exemplary Program

Massachusetts has demonstrated significant commitment to the installation of renewable energy technology along its roadways. The Massachusetts Department of Transportation (MassDOT) has installed solar arrays along six rights-of-way since October 2012, and has several other projects planned.

"These solar generation facilities will showcase MassDOT's commitment to sustainability and innovation," says MassDOT renewable energy specialist Hongyan Oliver.

In 2013, the agency initiated a statewide Solar Photovoltaic Energy Program to build enough ground-mounted solar photovoltaic facilities to generate up to 6 megawatts of power at multiple properties owned by the Commonwealth and located within the ROW. As MassDOT developed the program, the agency coordinated with the FHWA Massachusetts division to update its utility accommodation policy to include guidelines for renewable energy technologies installed on MassDOT real property or along its highways. The policy now outlines safety criteria and design standards, the project development process, compensation requirements, and license and lease agreements relevant to renewable energy projects on highways. The policy is available online at www.massdot.state.ma.us/Portals/8/docs/utilities/UAP.pdf.

To implement the program, MassDOT worked with a consultant to screen potential sites for their solar generation potential, considering shading, topography, existing drainage, ground utilities, proximity to electricity transmission lines, environmental concerns, any conflicting use, and visibility. Of more than 600 possible locations, surveyors identified 14 promising sites for ground-mounted solar panel systems. MassDOT's highway administrator ultimately endorsed 10 parcels at 8 locations for initial project development. Several of the parcels encompass acreage at interchanges and medians of I–90, which runs east-west. MassDOT is currently analyzing other State highway locations as potential sites in pursuit of its goal to reach or surpass 6 megawatts of power generation.

Partnering to Finance Renewable Energy Projects

Transportation agencies facing limited budgets may not have resources readily available to fund the installation of renewable energy facilities on their highway lands. Commonly, DOTs that have implemented highway renewable energy projects successfully have relied on public-private partnerships. Under one business model, for example, the State transportation agency would not provide any upfront capital for the project. Instead, it would partner with a utility or private developer that would finance, construct, maintain, and decommission the renewable energy facility. The developer would recover its investment over time by selling the electricity generated by the facility and by taking advantage of Federal and State tax incentives, if applicable.

The recent projects in Massachusetts offer an example of this business model. MassDOT selected a developer to design, construct, finance, operate, maintain, and decommission its solar facilities. Under this arrangement, all partners stand to benefit financially. The utility will have some of its demand for power offset by the new generating source. The developer will receive all of the projects' State solar renewable energy credits and tax incentives. And MassDOT, which did not use any State funding for capital costs on the projects, will purchase 100 percent of the electricity generated through a 20-year rate schedule that is significantly lower than the utility rates that MassDOT typically pays.

In addition, MassDOT will receive annual rent payments from the developer, which is leasing the land where the solar arrays are installed. MassDOT also benefits from the State's existing net metering policy, which allows host customers to obtain net metering credits for exporting any excess power generated from qualified distributed generation units back to the grid. Between the reduced electricity costs and the lease revenue, MassDOT stands to gain from its solar energy program. MassDOT has the option to either extend the contract or purchase the facilities at fair market value at the end of the 20-year initial contract period.

The Conversation Builds

State transportation agencies, renewable energy developers, utilities, and other stakeholders continue to express interest in evaluating highway ROW for innovative, sustainable uses. Some are viewing these projects as more than simply one-off projects, and rather as a

This 325-panel solar array located along I–91 in Northampton, MA, generates approximately 70 kilowatts of power, which offsets energy demand from a nearby office building. *Photo: Daryl Amaral, Massachusetts DOT.*

common way of doing business. As such, some State transportation agencies are paying close attention to regulatory, industry, and stakeholder developments in the renewable energy industry. Governmental policy changes could make highway ROW even more appealing for renewable energy development.

The ongoing awareness and appeal of these projects has helped motivate dialogue about the future. For example, the Transportation Research Board's Committee for Waste Management and Resource Efficiency recently established a new subcommittee on infrastructure, facilities, and rights-of-way as sustainable resources to share knowledge and research on the alternative and innovative use of transportation assets to support overall environmental and economic sustainability objectives.

There is ample reason to explore the subject further, as demonstrated by the pioneering transportation agencies that have installed renewable energy technologies in highway ROW. These projects can provide a way for State DOTs to offset their carbon footprints, meet sustainability goals, and help create or sustain a local, green job market. They can also help reduce highway maintenance and operational costs while potentially generating additional revenue for transportation agencies.

Although the collective experience with such projects is growing, State DOTs continue to face considerable economic, ecological, legal, and political challenges in developing and implementing renewable energy projects in the highway ROW. FHWA supports State DOTs' pursuit of these projects, and is a resource for information on issues that may arise and topics that States need to consider when designing, developing, and implementing renewable energy projects in the highway ROW.

Beyond Solar Panels

In addition to using solar panels to convert sunlight into electricity, some State transportation agencies are piloting or considering other sources of renewable energy for highway ROW, including wind, organic materials, and geothermal sources. Texas and Missouri DOTs have installed wind turbines near highways. Transportation agencies in Michigan, North Carolina, and Utah have partnered with the Freeways to Fuel National Alliance to explore the use of highway ROW for growing crops that can be processed into biofuels. Others have used geothermal technologies to help warm bridge decks or power rest areas. Applications involving hydrokinetic technologies (for example, harvesting energy from waves and tides to power turbines) may present viable options in the future.

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by Heather Shelsta

Making **Virtual** a **Reality**

(Above) A computer-generated island constitutes NHI's virtual campus, which includes an auditorium (center), an entrance area (right) for visitors to learn about NHI and the training event, and breakout rooms (left) for small group meetings.

NHI has delivered interactive, conference-style training directly to State DOT desktops.

State departments of transportation face increasing challenges in training their employees. Traveling to out-of-State conferences or training programs can be expensive and time consuming, and may not be feasible given travel restrictions, reduced budgets, and limited staff time. Moreover, a State DOT may not have enough staff members with the same training needs to host and fill a traditional instructor-led course onsite.

With such constraints, how can State DOTs effectively offer their staff the opportunity to hear from national experts about the latest technologies or policies, or the chance to network with peers in other areas of the country? To help, the National Highway Institute, the technical training arm of the Federal Highway Administration, recently tested a new approach: a virtual, interactive, conference-style training held in real time.

With support from FHWA's Geotechnical Team, NHI built a virtual world—a training facility with a lecture hall, breakout rooms, and exhibit space. In March 2015, NHI offered its first virtual training expo in the newly developed virtual space.

Bringing the Conference To the Desktop

NHI scheduled the training expo in conjuction with the International Foundation Congress and Equipment Expo (IFCEE), held in San Antonio, TX, to take advantage of the availability of subject matter experts in attendance as speakers. With 83 participants from 29 States, the training reached participants who could not otherwise attend IFCEE.

Virtual world technology is essentially enhanced Web conferencing that uses avatars to represent a participant's physical presence. Participants can customize an avatar to look like themselves, including gender, hair and skin color, height, and weight. Attendees can even customize their outfits—an opportunity to have a little fun at the event.

"Our virtual world platform has an orientation area where attendees can learn how to move their avatars in the space and collaborate with others," says Louisa Ward, a training program manager at FHWA who helped organize the event. "Evaluation results from this virtual world training showed that a number of attendees felt the use of avatars helped people stay more engaged than in a traditional webinar."

The ability to have one-on-one, small group, and large audience discussions is one of the benefits of the new technology. Voice over Internet Protocol (VoIP) enables participants to speak to others who are nearby—as a conference attendee might chat to others in surrounding seats—and to ask questions of the panelists and speakers. By replicating the type of interaction that attendees can experience in person at an event, the technology offers improvements over webinars and Web-based meetings, which do not offer the ability to have side conversations or small group discussions.

Jeffrey Sizemore, a geotechnical engineer with the South Carolina Department of Transportation, says about his State's participation in the virtual expo: "This innovative virtual training platform allowed SCDOT the opportunity to participate in the conference technology transfer without the actual physical travel. Interacting with experts in the different subjects and the large number of participants, all from our office desks, gave the sense of being at the conference, and was more conducive to learning."

Providing Expert Panels at a Distance

Conference-style training differs from traditional NHI training in that it offers access to numerous speakers on a variety topics, rather than a single course with one or two instructors. During the virtual expo, participants could attend keynote speeches and several technical panel sessions available only to the virtual attendees. They could also participate in live-streamed presentations taking place at IFCEE and a showcase featuring virtualized equipment and information on industry and construction advances.

For three of the sessions, Silas Nichols, a geotechnical engineer at FHWA, and the other organizers of the virtual event asked industry groups representing deep foundation design and construction to identify subject matter experts for each panel. He also asked them to develop discussion topics in advance of the conference about issues with construction practices and quality assurance on structure foundations. Finally, he asked them to prepare responses to frame the debate with State DOT engineers. The panelists and participants received the questions in advance so that they would be prepared to comment and facilitate a dialogue.

A fourth panel was a State-only session to discuss an emerging technical issue on foundations and begin developing a strategic plan for research and development. As in the industry-led panels, representatives from State DOTs developed questions in advance to focus the discussions and enable the panelists and participants to prepare comments and questions for one another.

To stimulate further interaction and facilitate debate, event organizers incorporated questions from polls conducted during the panels to solicit information from State DOTs about their practices. The moderator of each session could use the poll results to better direct questions to panelists and to enable States to see what their peers were doing in these technical areas.

Offering Exclusive Access to Lecturers

One of the significant benefits of conducting the training event from the site of the IFCEE conference was the availability of technical presentations. As part of the virtual conference, the event's organizers selected several IFCEE lectures by internationally recognized experts on structure foundations to broadcast to the participants. Industry experts being honored for their contributions to the field gave three of the presentations. The fourth lecture was the IFCEE conference keynote address by G. Wayne Clough, former secretary of the Smithsonian Institution.

During the broadcasts of the lectures, participants could comment to each other and the moderators via instant messaging. Following the broadcast, the speakers participated in moderated discussions that provided an exclusive question-and-answer opportunity for State DOT participants. This additional benefit was not available to attendees at the real-world conference in San Antonio.

Showcasing Innovations Virtually

The third component of NHI's conference was a showcase of equipment innovations and construction advances. This component required moving what normally would be an exhibit hall of displays and models to the virtual space. Manufacturers, contractors, and consultants created three-dimensional representations of equipment and offered informational videos and other materials. Virtual visitors could view the 3–D models and videos and download information from vendors.

"The goal of the showcase was to educate public sector engineers on equipment capabilities and limitations in a way that is usually restricted to in-person expos," says FHWA's Nichols. "It provided an opportunity for virtual attendees to engage industry experts and other State DOTs regarding structure foundations and construction of geotechnical features."

Using Technology To Overcome Limitations

Training delivery methods must continue to evolve to meet the challenges of limited budgets and travel restrictions. NHI is working with FHWA's Office of Information Technology Services to determine a platform that meets NHI training requirements as well as security requirements in order to offer future training events in virtual worlds.

The March 2015 event was well received as a special opportunity for State geotechnical and bridge engineers to easily access information on advances and innovations by connecting them with subject matter expertise in the geotechnical community. Participants indicated that they would like to participate in further conference-style training and expressed interest in the possibility of traditional, instructor-led NHI courses being delivered using a virtual format.

"The virtual campus gives NHI and the FHWA program offices a very different, yet effective platform for making external subject matter expertise available to State DOTs," says Nichols. "The ability to network with the semblance of a physical presence gives users a sense of participation within much larger peer groups than we have ever been able to provide through traditional learning environments."

Heather Shelsta is a training program manager at NHI. She holds a bachelor of science degree in foreign service and a master of policy management, both from Georgetown University.

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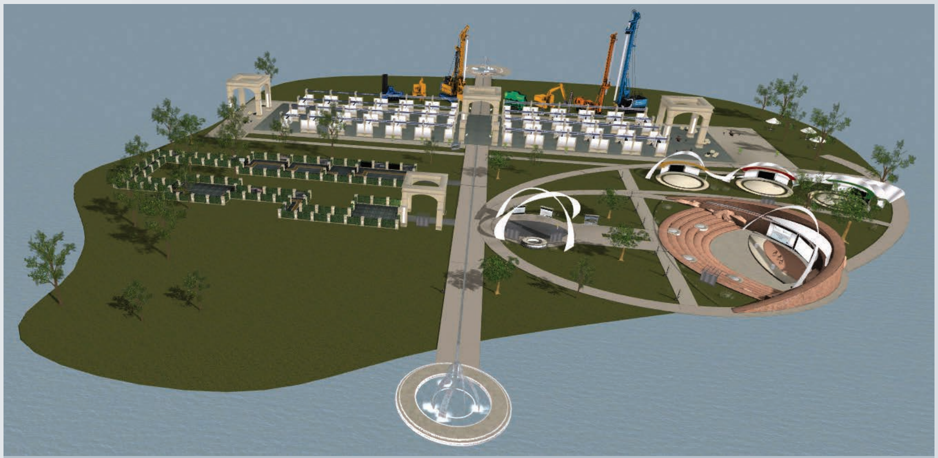


In addition to the auditorium, entrance, and breakout rooms, the virtual campus offers a long pavilion for exhibit booths and an expo space for 3–D equipment models, visible here at the far side of the island.

by Marcus A. Brewer and Rebecca Crowe

A Golden Opportunity To Make Travel More Golden

FHWA continues its increasingly important role of helping meet the needs of a growing demographic. Check out the **Handbook for Designing Roadways for the Aging Population.**

(Above) This older pedestrian crossing a busy intersection benefits from roadway treatments (high-visibility crosswalks and countdown signals) suggested in FHWA's latest edition of the *Handbook for Designing Roadways for the Aging Population*, released in June 2014. *Photo: AAA Foundation for Traffic Safety.*

How many U.S. drivers are getting older, becoming seniors, or aging into their "golden years"? Whatever is the best phrase, the U.S. population is definitely shifting. In 2012, 43.1 million people were age 65 or older. By 2030, according to the Administration on Aging, which is part of the U.S. Department of Health and Human Services, approximately 72.1 million will fit in that age category. Transportation professionals take note: By then, approximately one-fifth of the population in the United States will be older adults.

Although the number of fatalities and the fatality rate, both overall and among aging road users, has declined in recent years, people age 65 or older are still involved in a disproportionate share of fatal crashes compared with the population as a whole. People age 65 or older currently make up only about 13 percent of the Nation's population, but the National Highway Traffic Safety Administration's analysis of driver and crash data indicates that they represent approximately 16 percent of drivers, 16 percent of driver fatalities, and 20 percent of pedestrian fatalities.

With that in mind, the transportation community needs to consider the consequences of these changing demographics. This growing group of drivers, pedestrians, and other road users are experiencing declining vision; slowed decisionmaking and reaction times; exaggerated difficulty when dividing attention between traffic demands and other important sources of information; and reductions in strength, flexibility, and general fitness. The Federal Highway Administration ran a series of articles in PUBLIC ROADS in 2006 and 2007 that focused on these declining driving abilities.

In 2012, recognizing the need to focus on the aging road user, Congress included the Special Rule for Older Drivers and Pedestrians in the Moving Ahead for Progress in the 21st Century Act (MAP-21). States now are required to consider countermeasures if their rates of fatalities and injuries for older drivers or pedestrians show an increase during the most recent 2-year period.

In response to the surge in aging road users, FHWA released the *Handbook for Designing Roadways for the Aging Population* (FHWA-SA-14-015) in June 2014.

"Communities across the Nation recognize the transportation challenges facing older adults and are looking for methods to keep them safely on the move," says FHWA Associate Administrator for Safety Tony Furst. "Our new *Handbook for Designing Roadways for the Aging Population* is an excellent resource that gives States and localities detailed, proven practices that can be implemented to meet these challenges and improve the transportation system for all road users."

Ages 65 and Older: Changes in Population and Fatalities

History of the Handbook

More than 17 years ago, FHWA published the *Older Driver Highway Design Handbook* (FHWA-RD-97-135). This 1998 publication provided highway designers and engineers with the first source of practical information linking age-related declines in functional capabilities to enhanced design, operational, and traffic engineering treatments, keyed to specific roadway features. Experience with these enhanced treatments, including extensive feedback from local- and State-level practitioners, led to the release of the *Highway Design Handbook for Older Drivers and Pedestrians* (FHWA-RD-01-103) in 2001.

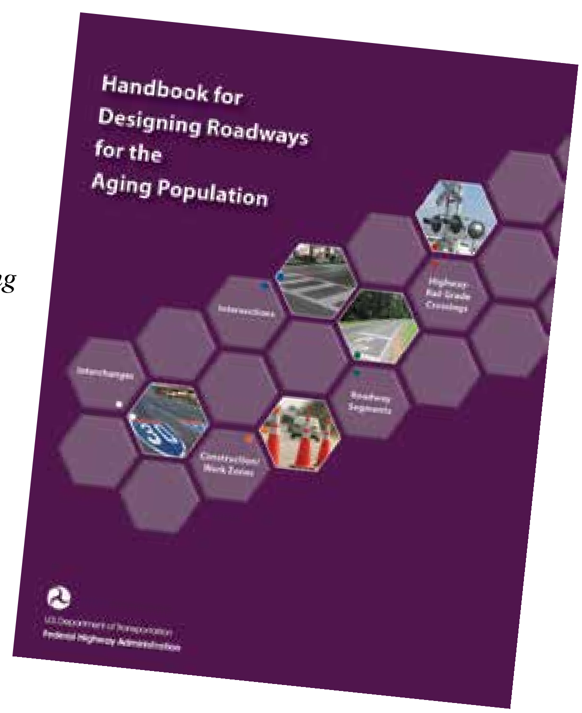
Now, FHWA has released a third version of this resource under the new title *Handbook for Designing Roadways for the Aging Population*. This latest version incorporates new research, expands the range of applications covered by the previous handbook, and introduces format changes that bring the guide into the digital age. Those changes include a Web-based version to facilitate access and use by engineering professionals who are reviewing and selecting *Handbook* recommendations to enhance safety on their community's or State's streets and highways.

Part I: Treatments

The 2014 *Handbook* is composed of two parts. The first presents recommendations for treatments and countermeasures that address specific areas of concern for aging road users. The second part presents the supporting evidence, rationale, and previous research results for each treatment. Four supplemental appendices include technical notes, photograph and image credits, a glossary, and an extensive list of references.

The treatments in the *Handbook* focus on five categories of roadway features, each containing a number of specific design elements for which guidance is provided. The five categories are as follows:

1. *Intersections* encompass a majority of the recommendations because numerous studies show that intersections are the most problematic areas with respect to crash frequency and severity involving aging drivers. Intersections also involve the greatest exposure to risk for pedestrians.
2. *Interchanges* are addressed with a focus on opportunities to improve difficulties with lane changing (merging/weaving) and wrong-way driving maneuvers.
3. *Roadway segments* place emphasis on horizontal curves (delineation) and provisions for passing zones.



This photograph shows advance pavement markings, which are described in chapter 3 of the first part of the *Handbook*. Large route shield markings like these should be used in advance of major freeway junctions to guide drivers to the correct lane. *Photo: Jim Lyle, Texas A&M Transportation Institute.*

4. *Construction work zones* represent opportunities to enhance path delineation and advance notice of road work. These treatments are warranted due to heightened tracking (steering) demands that may increase a driver's workload along with an increased potential for unexpected events that require a rapid response.
5. *Highway-rail grade crossings* are the final category. Although conflicts are rare, they can be unexpected and severe. Problems of detection (despite passive controls) may be amplified for aging drivers due to the sensory losses experienced with aging.

The *Handbook* contains descriptions of 51 treatments in these 5 categories, plus recommendations for their implementation. Nearly half of the treatments (24) pertain to intersections, such as left-turn treatments, signs, signals, lighting, and roundabouts. Another 8 treatments pertain to interchanges; these treatments are largely intended to improve the driver's information and intended actions at the approaches to entrance and exit ramps, although lighting and delineation of the ramps themselves are discussed as well. There are 10 treatments for roadway segments; many of these focus on improving the visibility and navigability of horizontal and vertical curves. Seven construction work zone-related treatments provide recommendations on the use of changeable message signs, static signs, and channelization for lane closures and other road work. Finally, the two treatments for highway-rail grade crossings (delineators and lighting) are intended to improve the visibility of crossings for approaching drivers.

Within each category of features, treatments are classified as proven practices or promising practices. The 33 proven practices are based on supporting evidence drawn from a comprehensive review of field and laboratory research addressing human factors and highway safety. The supporting information presented in part II represents the latest relevant information and data available to the authors at the time that the document was assembled. Some research findings have been carried forward from previous versions, while other findings are new since the release of the 2001 edition.

Promising practices include 18 additional treatments that are in use by one or more agencies around the country. Although FHWA has not evaluated them formally, they are believed to be of benefit to the aging population of roadway users. That conclusion is based on a subjective assessment by the FHWA staff participating in the development of the new edition of the *Handbook*.

For both the proven and promising practices, part I provides recommendations concerning their use in terms of specific design elements. In many cases, visual illustrations (that is, photographs or drawings) are included to provide examples of the treatments in use. In addition to the recommendations for the use of each treatment, the *Handbook* includes supplemental support from key references such as FHWA's *Manual on Uniform Traffic Control Devices* (MUTCD), the American

Another example of a recommended practice is this "jumbo" street sign, shown here in Phoenix, AZ.

Dan Nabors, VHB

The proven and promising practices described in the newest edition of the *Handbook* can benefit both older drivers and older pedestrians, such as this woman.

Association of State Highway and Transportation Officials' Green Book (*A Policy on Geometric Design of Highways and Streets*), the Institute of Transportation Engineers' *Traffic Engineering Handbook*, and other common guides.

Greg Johnson, chief operations officer at the Michigan Department of Transportation, says, "At MDOT, we have long recognized the need to adapt our system for the safety of users of all ages. We are following the latest research to improve the timing of WALK/DON'T WALK signals for pedestrians, but especially important is our attention to replacing signs that don't reflect well at night. Those signs might look fine in the light of day, but they lose reflectivity over time, and nighttime driving is a special safety priority."

Chapter 5 of part I of the *Handbook* recommends that some action words on portable temporary work zone signs have a minimum letter height of 8 inches (20 centimeters). According to Ed Yarbrough, construction safety engineer with the California Department of Transportation, "I conduct about 200 field reviews a year where the contractor has set traffic control. On a recent lane closure, I saw traffic control signage with a larger letter size. If these signs stand out to me and get my attention, then it is our hope that the larger lettering is having the same impact on the public, so that they can move through our work zones safely."

Part II: Rationale and Supporting Evidence

In part II of the *Handbook*, the specific chapters, figures, and tables from the key references are listed for each treatment, followed by a detailed description of relevant research that documents the supporting evidence for the recommendations made in part I. The material in this part of the *Handbook* represents, to as great an extent as possible at the time of its development, the results of empirical work with aging drivers and pedestrians for investigations into the specific highway features of interest.

The FHWA team gave precedence to naturalistic and controlled field studies, augmented by laboratory simulations employing traffic stimuli and relevant situational cues. In addition, part II contains citations of crash data as appropriate. Some citations also reference studies showing the effects of changes in roadway design, where the predicted impact on the performance of aging drivers is tied logically to the results of research on age-related differences in detection, comprehension, response selection, maneuver execution, or other capabilities needed to negotiate the design element safely.

Comment and Conclusion

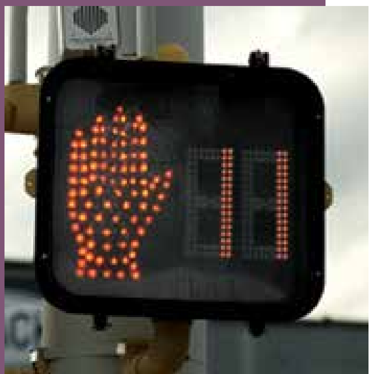
The treatments presented in the *Handbook* do not constitute a new standard of required practice. The final decision about when and where to apply the treatments remains at the discretion of State and local design and engineering professionals.

The 2014 *Handbook* is a resource that they can apply preemptively to enhance safety in jurisdictions with high numbers of aging road users, or it may be employed primarily as a problem-solver at crash sites. The transportation community can apply *Handbook* treatments in the design of new facilities and planned highway reconstruction projects, or use it to make improvements to existing facilities. The implementation of these treatments is intended to translate into real gains in safety and mobility for aging drivers, and many of the treatments have potential benefits for all users of the surface transportation system.

Before the new version of the *Handbook* was completed, Congress passed the MAP-21 transportation authorization bill. MAP-21's Highway Safety Improvement Program, 23 U.S.C. 148(g)(2) states the following: "If traffic fatalities and serious injuries per capita for drivers and

Example From the *Handbook*: Street Name Signs

"The MUTCD (2009) specifies that the lettering on street name signs should be at least 6 [inches, in] [15 centimeters, cm] for uppercase letters and 4.5 in [11 cm] for lowercase letters, and that larger letters should be used for street name signs that are mounted overhead. It provides an option for using 4-in [10-cm] uppercase lettering and 3-in [8-cm] lowercase lettering on street name signs that are posted on local roads with speed limits 25 [miles per hour] [40 kilometers per hour] or less. . . . The selection of letter size for any sign must evaluate the needs of the user, which are continuously changing as a function of changes in automotive technology, the roadway system, and the population itself. For example, Phoenix, Arizona, a city with a large aging driver population, has been using 'jumbo' street name signs at signalized intersections since 1973. These signs are 16 in [41 cm] high and use 8-in [20-cm] capital letters. . . . It is estimated that by the year 2020, 17 percent or more of the population will be older than 65 years of age, and by the year 2030, 1 in 5 Americans will be older than age 65. . . . The ability to read street signs is dependent on visual acuity as well as divided attention capabilities, both of which decline significantly with advancing age."



David Harkey, Highway Safety Research Center, University of North Carolina

According to research, the countdown pedestrian signal is easier for older adults to follow than other pedestrian signals.

pedestrians over the age of 65 in a State [increase] during the most recent 2-year period for which data are available, that State shall be required to include, in the subsequent Strategic Highway Safety Plan [SHSP] of the State, strategies to address the increases in those rates, taking into account the recommendations included in the publication of the Federal Highway Administration entitled *Highway Design Handbook for Older Drivers and Pedestrians* (FHWA-RD-01-103), and dated May 2001, or as subsequently revised and updated."

In 2013, four States—Alaska, Arkansas, Rhode Island, and Tennessee—reported that they fell under this special rule. In 2014, five States—Alaska, Arkansas, Hawaii, Maine, and Tennessee—were required to follow the rule. Since 2013, the Tennessee Department of Transportation (TDOT) has worked diligently to update its strategic highway safety plan to ensure that it addresses older drivers and pedestrians.

In January 2015, TDOT announced its updated plan. Under the infrastructure improvements emphasis area, strategy 6 specifically refers to improving "the safety of senior drivers by reducing roadway geometric deficiencies and enhancing roadway visibility on State and interstate highways."

According to Brian Hurst, manager of TDOT's Project Safety Office, "TDOT is addressing safety for all roadway users, including the growing population of senior drivers. The department has systemically increased the size of signs and striping along State-maintained roadways. The larger geometric roadway warning signs improve the distance [from which] a sign can be seen."

In an effort to ensure knowledge sharing, FHWA and NHTSA are developing a Clearinghouse for Older Road User Safety, or ChORUS. FHWA and NHTSA envision this clearinghouse devoted to the safety of older road users as a one-stop shop for transportation officials, community leaders, older drivers, and their families and caregivers. The agencies will fill the clearinghouse with information about safer road designs for older road users, including drivers, pedestrians, cyclists, and persons with mobility or cognitive impairments; cost-effective roadway countermeasures to improve community safety for all; licensing information and policies; and other resources.

FHWA is working with the Roadway Safety Foundation to develop and manage the site along with NHTSA and its contractor. The clearinghouse will include a community forum and discussion boards where users can interact, and will be optimized for desktop computers, tablets, and other mobile devices from the outset. The goal is to have the clearinghouse up and running by the end of 2015.

FHWA Acting Administrator Gregory Nadeau underscored the agency's commitment to the aging road user in his opening remarks at the 2014 North American Conference on Elderly Mobility: "We'll intend to work closely with our Federal, State, local, and nonprofit partners by engaging in research and knowledge sharing that will provide safe mobility for older road users."

A classic road diet, included as a promising practice in the *Handbook*, reconfigures the roadway from four lanes to three, with two through lanes and a center two-way left-turn lane, as shown in these before (left) and after (right) photos of Soapstone Drive in Reston, VA. A Michigan study found that treating corridors with road diets reduced crashes involving aging drivers by 39 percent. *Photos: Virginia Department of Transportation.*

There are a number of good reasons for FHWA, State DOTs, and local agencies to improve safety for older adults. Roadway designs that help older adults tend to be safer for everyone, regardless of age. And, if you are not over 65 years old already, you will certainly benefit from these safety improvements when you become part of the older, golden, or senior population.

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Rebecca T. Crowe is a transportation specialist with FHWA's Office of Safety. Crowe has been with FHWA for 14 years and manages the Older Road User program in addition to the Road Safety Audit, Motorcycle Safety, and Road Diet initiatives. She holds a B.S. in urban studies and planning from Virginia Commonwealth University and a master's degree in transportation planning, operations, and logistics from George Mason University.

For more information, see the Handbook for Designing Roadways for the Aging Population, *which is available in HTML and PDF formats through the Web site of the FHWA Office of Safety at http://safety.fhwa.dot.gov/older_users/handbook. Or contact Rebecca Crowe at 804-775-3381 or rebecca.crowe@dot.gov.*

North American Conference on Elderly Mobility

On May 12, 2014, FHWA Acting Administrator Gregory Nadeau welcomed participants to the North American Conference on Elderly Mobility, which was held in Detroit, MI. The conference highlighted best practices from around the globe to improve mobility for older adults. FHWA staff from the Michigan Division, Office of Safety, and Turner-Fairbank Highway Research Center participated in the conference.

In 2004, the Michigan DOT held the first elderly mobility conference, and, since that time, advances have occurred in older adult mobility and safety. The 2014 conference provided an update and evaluation of best practices since the 2004 conference. An engineering highlight of the recent conference was a $200,000 effort by the Michigan DOT to modify a 7.3-mile (11.7-kilometer) roadway to improve traffic control devices for the aging population. The DOT offered van tours to participants to view a side-by-side comparison of treatments.

The North American Conference on Elderly Mobility: Best Practices From Around the World—A Decade of Progress took place on May 11–14. In the fall of 2014, FHWA released the *North American Conference on Elderly Mobility Noteworthy Practices Guide* (FHWA-SA-14-095), which showcases practices to improve elderly mobility. Access the guide at http://safety.fhwa.dot.gov/older_users/noteworthy.

Michigan DOT

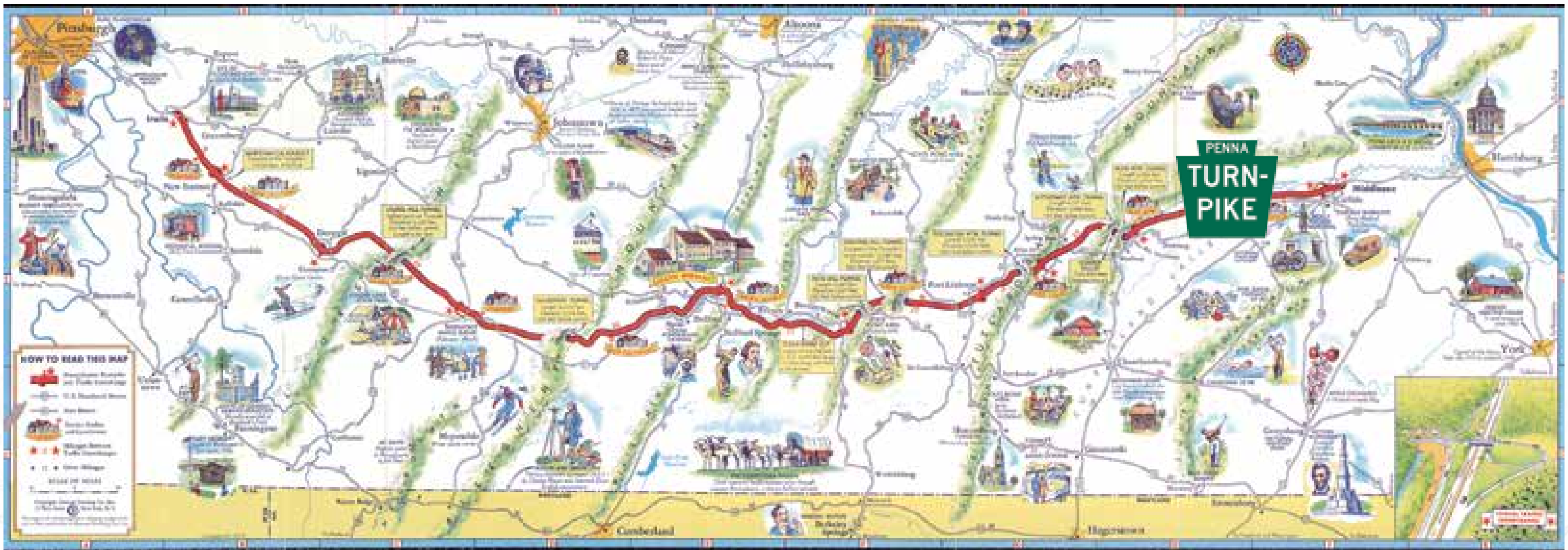
Florida DOT

Pedestrian signals need to allow sufficient time for older adults and all other walkers, like these women, to cross safely.

The Pennsylvania Turnpike Turns 75

by Richard F. Weingroff

The Pennsylvania Turnpike, shown here near milepost 83.6 eastbound between the New Stanton and Donegal interchanges, opened to traffic 75 years ago this fall. *Photo: Pennsylvania Turnpike Commission.*



The original Pennsylvania Turnpike stretched from U.S. 11 at Carlisle to U.S. 30 at Irwin, as shown on this map. *Photo: Pennsylvania Turnpike Commission.*

On this diamond jubilee, it's easy to lose sight of just how revolutionary the Nation's first superhighway really was.

Toll advocates will probably never let the Federal Highway Administration forget one of the most embarrassing mistakes in its 122-year history.

In a landmark 1939 report to Congress, *Toll Roads and Free Roads*, the Bureau of Public Roads—FHWA's predecessor—explained that based on origin-and-destination surveys conducted around the country, plus the availability of free routes, most corridors would not generate enough revenue from tolls to retire the bonds that financed construction.

For example, a roadway under construction from Pittsburgh to Carlisle, PA, was expected to carry only 715 vehicles per day. Most of this corridor would eventually make up the first section of what became the Pennsylvania Turnpike. The forecast for the Pittsburgh-Carlisle segment, low as the number was, represented the 19th highest traffic volume of all the potential toll superhighways studied at the request of Congress.

Historian Dan Cupper has pointed out that the Pennsylvania Turnpike, when it opened, "completely defied the pessimistic predictions." And that's putting it mildly.

Toll Roads and Free Roads, which President Franklin D. Roosevelt sent to Congress on April 27, 1939, a year and a half before the turnpike opened, also contained a "master plan" for what became the Dwight D. Eisenhower National System of Interstate and Defense Highways, so it wasn't a total loss.

The Granddaddy of The Interstate System

In July 1940, the trade magazine *Better Roads* referred to the Pennsylvania Turnpike as a "modern experiment in long-distance toll highways" whose outcome was uncertain. As the country considered how to build a superhighway network, the magazine said, the turnpike "may serve to a certain extent as a test of the feasibility of toll financing."

What nobody knew on October 1, 1940, the day the Pennsylvania Turnpike opened, was that it would not only be financially successful, but also serve as a model that many States continue to follow to this day. The Pennsylvania Turnpike method of bond financing for the construction of expressways, with repayment through toll collection, would become a template that more than a dozen States followed before 1956, and it has been duplicated in multiple variations ever since.

The turnpike also provided a design model that would be repeated, with upgrades, for the interstate system, minus the turnpike's commercial service plazas. For that reason, turnpike officials have referred to it as the "granddaddy" of the interstate system.

For most motorists at the time, it was the first superhighway they could travel safely at high speeds in their own cars. Terms such as "dream road" and "magic carpet ride" were used in the turnpike's early years to describe a driving experience that is now so routine that motorists barely notice it as they make time on the country's toll and nontoll interstate highways.

Today, the original Pennsylvania Turnpike has been extended to 360 miles (579 kilometers), reaching from the Ohio Turnpike (opened in 1955) to the New Jersey line at the Delaware River-Turnpike Toll Bridge (opened in 1956). In addition, the Pennsylvania Turnpike Commission (PTC) operates the Beaver Valley Expressway, the Mon/Fayette Expressway, the Amos K. Hutchinson Bypass (also called the Greensburg Bypass), and the Southern Beltway, for a total length of 552 miles (888 kilometers) of toll facilities in Pennsylvania. Those additional miles were built on a proven model, but the innovative first 160-mile (257-kilometer) section was made possible by the failed business ventures of two 19th-century railroad empires determined to destroy each other.

The Folly That Made The Turnpike Possible

On one side was William Henry Vanderbilt, the eldest son of Commodore Cornelius Vanderbilt, who built a multimillion-dollar steamboat and railroad empire that William inherited. William Vanderbilt is best known today for his response to a reporter's question in 1882 about whether he should retain an unprofitable New York-to-Chicago train to serve the public. He replied, "The public be damned!" (Historians differ on the context and precise wording. He may have added, "I am working for my stockholders! If the public want the train why don't they pay for it?")

On the other side was George B. Roberts, a civil engineer who became president of the Pennsylvania Railroad (Pennsy) in 1880 and whose New York-to-Chicago line was the main reason Vanderbilt was running his line at a loss.

The railroad industry as a whole was engaged in ruthless competition involving such practices as undercutting rates, redirecting service to gain greater shares in the same markets, and manipulating stocks. Vanderbilt was determined to undermine the Pennsy after it gained control of a line along the west bank of the Hudson River that would rival Vanderbilt's line on the east bank. With financial help from Andrew Carnegie and other wealthy associates, Vanderbilt began building the South Pennsylvania Railroad parallel to the Pennsy line in western Pennsylvania. In response to this attempt to undermine the Pennsy, Roberts announced that he would "smash the South Penn like a bubble!"

In 1884, Vanderbilt's crews began work on nine tunnels through mountainous terrain, a bridge across the Susquehanna River, and grading for the double-track line between the State capital at Harrisburg and Pittsburgh. According to author William H. Shank, "By September of 1885, the railroad was 60 per cent finished, . . . [nine] tunnels had been excavated, and more than five million cubic yards [four million cubic meters] of grading had been completed." Vanderbilt had invested $10 million in the line, which cost 27 workers their lives, "mainly in the dangerous work in the tunnels, with blasting powder, pick and shovel, and occasional cave-ins."

On October 27, 1938, Walter Adelbert Jones, chairman of the PTC, put foot to shovel for the groundbreaking ceremony in Cumberland County to begin construction of the turnpike. Shown left to right: contractor L. M. Hutchinson, PTC Commissioner Charles T. Carpenter, Chief Engineer Samuel Marshall, Associate Regional Director G. Douglas Andrews of the Pennsylvania office of the Public Works Administration, PTC Chairman Jones, the Public Works Administration's State Director Edward N. Jones, PTC Commissioner Frank Bebout, and Colonel F. E. Lamphere of the Reconstruction Finance Administration.

Pennsylvania Turnpike Commission

Financier J. Pierpont Morgan was concerned that competitive overbuilding of railroads was weakening the railroads and the national economy, with the battle between the two Pennsylvania rail lines as exhibit A. Considering Vanderbilt's and Roberts' determination to crush each other's line, getting them to consider a truce wasn't easy. However, in July 1885, Morgan managed to get them and their associates onto his yacht, *Corsair*, to broker an end to their dispute.

Under the deal, Roberts agreed that the Pennsy would buy the southern line while Vanderbilt acquired the West Shore railroad. As a result, historian Cupper wrote, "On September 12, [1885] . . . work was halted so abruptly that laborers left their tools where they lay."

The battle between the two big railroad companies has become known as "Vanderbilt's Folly," but the battle left behind a construction legacy that a half century later made the Pennsylvania Turnpike possible.

"Come Tour the Future"

During the Great Depression, promoters conceived grandiose superhighway concepts that had several common themes, as illustrated by a plan that Senator Robert J. Bulkley (D-OH) proposed in the late 1930s. Under his plan, a U.S. highway corporation would build three transcontinental and seven north-south superhighways, each straight as an arrow, on 300-foot (91-meter) right-of-way, linked by spurs and connectors. It would accommodate trucks, railroads, even airplanes. His superhighway system would be financed by tolls and by leasing or selling the excess land. Like other visionary promoters, Senator Bulkley underestimated the cost and overestimated ridership, so it appeared that the financing plan would work without requiring tax dollars.

His proposal was similar to many others, but it was unusual in the amount of publicity it received, partly because President Franklin D. Roosevelt endorsed it. On February 2, 1938, Senator Bulkley discussed the plan with President Roosevelt, a long-time road booster who wanted to help the Senator's reelection bid. According to *The New York Times*, "The President was reported to have told the Senator that he had been thinking of a similar plan for some time, and to have told him to draft a bill."

Despite the President's interest, the Bulkley plan was not enacted (and the Senator lost his reelection bid). Nor were any of the other similar superhighway schemes that offered such promise to U.S. motorists.

A year after the Bulkley plan failed, however, the most popular exhibit at the 1939 New York World's Fair was General Motors Company's Futurama, a 35,000-square-foot (3,252-square-meter) model of transcontinental surface transportation in the world of 1960. It was as if all of those visionary schemes were displayed in miniature reality. Visitors in armchairs were transported around the exhibit for what a brochure called "a magic Aladdin-like flight through time and space" while speakers built into the seats provided the narrative. Futurama depicted interstate travel on single-direction, seven-lane highways, divided to accommodate designated speeds of 50, 75, and 100 miles per hour (mi/h) (80, 121, and 161 kilometers per hour [km/h]). Ten thousand scale model cars moved through the countryside. Experts in traffic control towers would use radio signals to let drivers know when to move from one lane to another. Radio beams on each end of the car would keep spacing even. Cloverleaf interchanges would allow motorists to move among roadways without reducing their speeds.

Thomas H. MacDonald, commissioner of the Public Roads Administration (another name for FHWA's predecessor agency), was not a fan of the superhighway schemes or Futurama. In a January 1940 speech, he lamented that the master plan for a toll-free express highway system in *Toll Roads and Free Roads* had not prevented the fracturing of interests among highway advocates, especially those glorifying transcontinental superhighway networks. As far as he was concerned, only "downright selfishness" would cause rejection of the master plan that depicted "fair and honestly balanced programs in the use of highway revenues."

In contrast to the Bureau of Public Road's data and page after page of text in support of MacDonald's point, the Futurama brochure urged visitors to "Come Tour the Future." MacDonald's master plan, for now, would have to wait.

Pennsylvania Gets Started

While dreaming of superhighways, motorists had to drive on the network of U.S. numbered highways. The network consisted of many paved, mostly two-lane highways such as U.S. 30, a transcontinental route from Atlantic City, NJ, to Astoria, OR. On November 5, 1935, U.S. 30 became the first transcontinental highway paved from end to end. President Roosevelt sent a congratulatory telegram. "The perilous trail of the pioneers is at last transformed, by joint efforts of the Federal and State Governments, into a coast to coast highway."

In Pennsylvania, U.S. 30 (the Lincoln Highway west of Philadelphia) was paved, but as Professor Tom Lewis explained in *Divided Highways*, the road was inadequate for the traffic using it. According to Lewis, the road was "narrow, steep, icy in winter, and often clogged with interstate truck traffic." Under the best conditions, a trip across the State on U.S. 30 took 10 hours; but under bad conditions, the trip became "an even longer and more arduous ordeal" of 12, 13, 14 hours.

Given these deficiencies, Pennsylvania officials began thinking about an "all-weather" toll superhighway from Irwin, near Pittsburgh, to Carlisle, near Harrisburg. With the country in the grip of the Depression, paying for it was the challenge. The key proved to be Vanderbilt's Folly.

On April 23, 1935, State Representative Cliff S. Patterson of Monongahela introduced House Resolution 138 to authorize a feasibility study regarding turning the abandoned roadbed and tunnels into a turnpike. Victor Lecoq of the State Planning Board and William Sutherland of the Pennsylvania Motor Truck Association had suggested the idea as a way of reducing the cost of the turnpike, thus making the project slightly less impossible to finance. The resolution called for funds from the Works Progress Administration (WPA) to pay for the study. With State legislators eager to go home as the session ended, they quickly approved the resolution which, after all, did not involve an expenditure of scarce State funds.

WPA's State Administrator Edward N. Jones and State Secretary of Highways Warren Van Dyke turned to WPA's chief Harry L. Hopkins, who had advocated express highway projects as job creators during Roosevelt administration internal

This photograph from the opening day brochure contained the following caption: "Slashing a 73-foot [22-meter] gash through high Negro Mountain, the Pennsylvania Turnpike by this cut avoids use of a half-finished tunnel hidden by trees at the left. This engineering triumph saves money."

Pennsylvania Turnpike Commission

discussions. Hopkins provided a WPA grant for the study, which got underway in January 1936.

With favorable results in hand, Patterson introduced Act 211, the Patterson Turnpike Act, on March 9, 1937. The law authorized creation of the PTC to build, without a cent of State funds, a turnpike from U.S. 11 near Harrisburg to U.S. 30 near Pittsburgh. The State legislature approved Patterson's bill, which Governor George H. Earle signed on May 21, 1937.

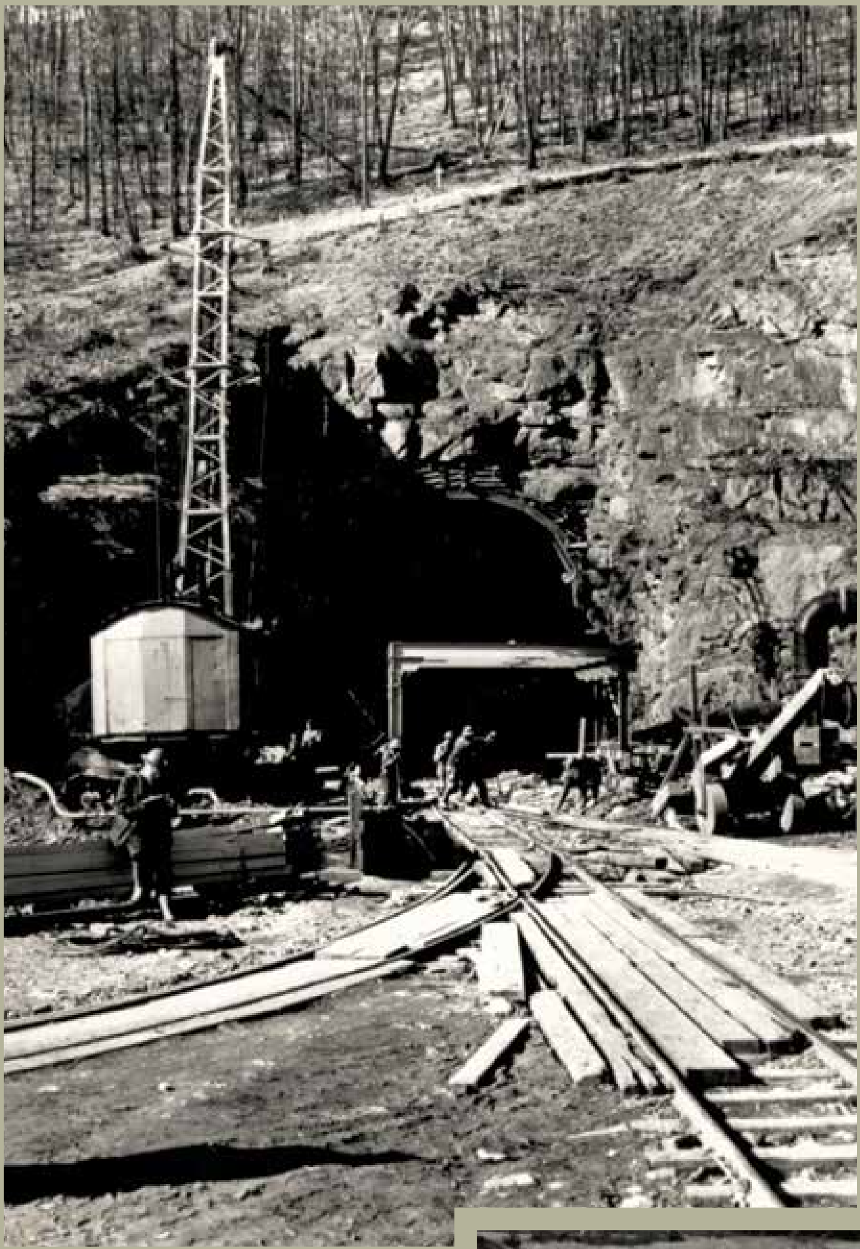
Passing a law to build a turnpike that would not cost the State a penny was the easy part. Now, the PTC would have to find a source of funds to pay for the job.

Tracing the Money Trail

To chair the commission, Governor Earle appointed Walter Adelbert Jones, a millionaire businessman who knew nothing about roads but had supported the Governor's election in 1934.

Critics questioned the Governor's choice of Jones, but he proved invaluable in launching the turnpike. His contributions to national political campaigns, initially to the Republicans in power in the 1920s, now to the Democrats in power in the 1930s, gave him connections within the Roosevelt administration that enabled him to find the needed money.

One of the first orders of business was acquiring the former South



Pennsylvania Turnpike Commission

(Above) Construction of the East Kittatiny Tunnel was delayed when workers "struck a watery seam of sand, releasing 500 to 1,000 cubic yards [382 to 765 cubic meters] of red, green, and black sand into the tunnel," according to historian Dan Cupper. Tunnel walls had to be redesigned as a result.

Pennsylvania Turnpike Commission

(Right) On August 6, 1940, before the turnpike opened, the National Guard's 108th Field Artillery battalion used the turnpike for summer maneuvers. Shown here are local residents watching as the military caravan rode the turnpike to "save" the town of Bedford from invasion.

This Blue Mountain facility was 1 of 10 service plazas where motorists could get food or gasoline without leaving the turnpike.

Pennsylvania Turnpike Commission

Pennsylvania Railroad right-of-way, then owned by subsidiaries of the Pennsy and the Baltimore and Ohio railroads. The subsidiaries didn't take the turnpike project seriously; they agreed on a sale for $1 million. When they realized the turnpike was actually going to be built, they boosted the price to $6 million. Eventually, with the help of the Reconstruction Finance Corporation, negotiations brought the price down. For $1 million to each of the subsidiaries, the PTC bought Vanderbilt's Folly.

As construction neared in 1938, PTC officials found that bankers were hesitant to buy the bonds for the project. Bankers had supported bonds for bridges such as the San Francisco-Oakland Bay Bridge (opened November 12, 1936) and the Golden Gate Bridge (May 27, 1937), where motorists had little choice but to pay the toll. Bonds for a 160-mile (257-kilometer) toll highway, lacking the full faith and credit of the State and parallel to a toll-free highway just a few miles to the south, did not appear to be the same type of safe investment. The PTC had to withdraw its initial $60 million bond offering.

Jones turned to President Roosevelt, who directed the Reconstruction Finance Corporation to buy $35 million in turnpike bonds (later increased to $40.8 million). The corporation conditioned the purchase on the PTC securing a grant from the Public Works Administration to cover 45 percent of the construction cost. Much to the commission's disappointment, the President approved only $20 million in Public Works Administration funds, leaving the PTC short of the Reconstruction Finance Corporation's condition. Hearing of this disappointing figure, Chairman Jones recalled, "our hopes seemed about to be dashed."

The President was in San Francisco on his way to San Diego, where he would board the USS Houston for a fishing expedition off the Galapagos Islands. Hoping to catch him before the ship departed, Chairman Jones sent a telegram to the President about the predicament. President Roosevelt replied, "I'll let you have $25 million."

With an additional million from the U.S. Department of the Interior, the PTC was ready for construction, which began on October 27, 1938, with a ceremonial turning of earth on a farm in Cumberland County.

From Vision to Reality

In contrast with the Bulkley and many other superhighway schemes of the day, the PTC created a design for the Pennsylvania Turnpike that pulled reality out of the visionary clutter. The commission acquired a 200-foot (61-meter) right-of-way for the four-lane divided turnpike. Traffic lanes, paved in concrete, were 12 feet (3.7 meters) wide with a 10-foot (3-meter) median and 10-foot (3-meter) shoulders, for a total width of 78 feet (24 meters). Engineers settled on maximum 3-percent grades and 6-degree curvature, with substantial superelevation, or banking, on curves. The design eliminated all at-grade crossings and included 11 interchanges.

The turnpike incorporated six of the South Pennsylvania tunnels, with a seventh built for the turnpike. The old tunnels presented challenges for 20th-century engineers. In the 1880s, workers had built the tunnels from both ends but had not bored through the center. Further, the tunnels had been designed for two tracks, but ultimately were built wide enough only for a single track. The result, as Cupper pointed out, was that "turnpike engineers found the tunnels with wide portals or entranceways, but narrower in their deepest reaches." Within the tight contract deadlines, turnpike contractors, working round-the-clock, completed widening the bores to create a roadway of 23 feet (7 meters) to carry two lanes of traffic moving in opposite directions.

Cupper quotes engineer Charles Noble about another key feature—uniformity of design: "Unlike the existing highway system of the United States, in which design standards fluctuate every few miles, depending on the date of construction, the turnpike will have the same design characteristics throughout its 160-mile [257-kilometer] length. Every effort has been directed toward securing uniform and consistent operating conditions for the motorist."

The turnpike included 10 commercial service plazas where motorists could stop for food and fuel. The Standard Oil Company, which secured the concession, built Esso service stations in each plaza and subcontracted with the Howard Johnson chain to provide restaurants. Motorists would not have to leave the turnpike—and pay additional tolls—for these services.

MacDonald, while skeptical of the toll aspect of the turnpike, "kept a wary eye on the events in Pennsylvania," as Professor Lewis

Pennsylvania Turnpike Commission

Pennsylvania Turnpike Commission

During World War II, the turnpike's service plazas employed women to check the oil and pump gas—jobs usually performed by men who had left for military service.

recounted. MacDonald's respect "for the turnpike's chief engineer, Samuel Marshall, and the staff he assembled to complete the project far outweighed the differences MacDonald had with Walter Adelbert Jones about the efficacy of a toll road." Marshall and MacDonald exchanged information and ideas on design issues such as "drainage, width of the median strip, composition of the roadbed, and thickness of the concrete." MacDonald's staff kept files of press reports, PTC public relations brochures, and PTC officials' speeches.

The Grand Preview

As contractors raced to finish the turnpike, the opening date kept slipping beyond July 4, 1940. The PTC did not finalize the toll fees until September 11. The delay was partly because the Pennsylvania Motor Truck Association, which had worked hard to gain public and political support for the turnpike, complained about the tolls that truckers would have to pay. The initial rates approved in September were $1.50 for passenger vehicles, $2.25 for a round trip. Truck rates ran according to weight and vehicle class ($3 to $10).

On August 26, 1940, the PTC previewed the road for more than 160 dignitaries, including Members of Congress, reporters, MacDonald, and other Washington officials. During a dinner for the group at the Hotel Hershey near Harrisburg the night before, MacDonald called the turnpike "a magnificent accomplishment that will be a monument to the foresight of its builders." He said, "This highway represents the best in American practice." Referring to the turnpike as "a strategic military route," he said it was "very necessary to extend this road to Philadelphia."

The New York Times described the tour: "Not a word of dissent was heard as the fifty-car motorcade roared over the 160-mile [257-kilometer] concrete turnpike, built for speeds up to 120 miles an hour [193 km/h]. Rain fell during the entire tour of inspection, but it was no deterrent to the drivers, who sped along without interference from traffic lights and grade crossings."

The *Times* described the toll plazas as "modernistic in design and finished in blue glass" and said the two-lane tunnels were "well lighted and specially ventilated." East of Bedford, the motorcade stopped at the Midway service plaza for lunch.

That evening, Jones sponsored a dinner at the Duquesne Club in Pittsburgh. Due to illness, Jones was unable to attend, but he telephoned a message to the previewers. "Imagine a great road stretching from New Orleans to Boston and bypassing all small towns. . . . Pennsylvania has shown the way with this great new road."

According to the *Times*, Representative Wilburn Cartwright (D-OK), chairman of the U.S. House Committee on Public Works and a strong proponent of superhighways, was one of the "most enthusiastic 'previewers.'" "This road is absolutely extraordinary," he said. "I think we should have roads leading to and from it from other eastern cities." He said it was "better than anything Germany can build," and "we're going to have to build more of them as traffic demands." He declared the Pennsylvania Turnpike "the mother of them all."

General Jacob L. Devers, representing Secretary of War Henry L. Stimson, predicted that the turnpike would be beneficial "in war as well as peacetime." He said, "The importance of the road for the transport of Army supplies cannot be minimized, particularly as it leads to one of the most vital cities [Pittsburgh] in the Nation's defense."

The Open Road

The turnpike opened at 12:01 a.m. on Tuesday, October 1, 1940, without ceremony but with a long line of vehicles at both ends eager to test the new road. One of PTC's engineers, Harry Lundy, recalled, "Nobody had ever seen a road without stoplights, intersections, steep hills, and sharp curves."

Initially, because the engineers thought that they had eliminated 95 percent of the causes of crashes, the turnpike also had no speed limit. Before the turnpike opened, Governor Arthur James announced that a speed limit of 50 mi/h

(80 km/h) would be in effect, but the ruling was "flatly ignored by both the motoring public and the Turnpike detail of troopers," according to Cupper. According to the Ford Motor Company, "the closest the average American comes to breaching the sonic barrier is when he eases himself behind the wheel of the family car and has a go at the Pennsylvania Turnpike." This opportunity would not last long, however. Governor James signed Act 10 on April 15, 1941, setting a speed limit of 70 mi/h (113 km/h) for cars, with a variable limit of 50 to 60 mi/h (80 to 97 km/h) for trucks based on size and weight.

During the first 4 days of operation, the "magic motorway" carried 24,000 vehicles. On the first Sunday of operation, Chief Engineer Marshall estimated that 27,000 vehicles used the turnpike, jamming the exits during peak periods and bringing traffic to a standstill for miles. A week after the opening, *Engineering News-Record* reported that the PTC had "decided that the exits on the superhighway are inadequate."

Despite the trouble at the exits, the road continued to receive rave reviews. *The New York Times* described the "Dream Road" for readers who might not understand the full scope of the project. Such a highway "has been seen hitherto only in miniature at the Futurama at the World's Fair." It was a "superspeed, supersafe route, the longest of homogeneous design in the country." It featured "great tunnels" and "amazingly deep cuts where, from the approaching car, it looks as if some super-Paul Bunyan had gouged a great, blunt-ended, pie-shaped segment out of the surface of the brown earth." After summarizing the design features, the *Times* wrote, "The result of these combined characteristics of the new road is to work a sort of driving magic."

By the end of 1940, the turnpike had carried 514,231 cars, 48,170 trucks, and 2,409 buses. Revenue from tolls reached $562,464. By October 1941, the turnpike had carried 2.4 million vehicles, far ahead of the projected 1.3 million.

Motorists no longer had to plan a trip to Germany's autobahn superhighways to see such roads—they had only to drive to Pennsylvania. According to *Fortune* magazine, "The Turnpike is the first American highway that is better than the American car. . . . It is proof against every road hazard except a fool and his car." A future FHWA official, W. Lee Mertz, recalled his first venture onto the turnpike in 1943, while still in the service. "I felt that I had just entered a different world, like Dorothy in the *Wizard of Oz*, and I was on the Yellow Brick Road." He added, "I had never seen anything like it."

This photograph shows the tollbooth at the Irwin interchange shortly after opening in 1940.

Pennsylvania Turnpike Commission

Pennsylvania Turnpike Commission

On August 26, 1940, members of the Pennsylvania Turnpike Commission and other dignitaries previewed the turnpike. They are shown here clustered around their cars in front of Blue Mountain tunnel. According to *The New York Times*, the previewers gave their "emphatic approval" to the turnpike.

Expanding the Model

The turnpike resolved questions about the nature of a superhighway. The Bulkley, Futurama, and other visionary superhighway concepts seemed to be from a future that America could not afford in the present. The Pennsylvania Turnpike was a real-life example of what a superhighway, built within current budgets and using current engineering skills, could be, with or without tolls. The turnpike was, in short, an object lesson for those planning the next generation of highways.

FHWA's bicentennial history, *America's Highways 1776–1976*, says of the turnpike: "The Pennsylvania Turnpike was the prototype of the modern high-speed heavy-duty Interstate highway. It incorporated the most advanced practice of German and American design engineers on highway grades and curvature and was hailed by many as the safest highway in the world."

The immediate financial success of the Pennsylvania Turnpike also proved enticing to officials from other States. "By 1941," historian Bruce Seely wrote in *Building the American Highway System*, "five States—New York, Maryland, Maine, Florida, and Illinois—had created toll road commissions." However, the Nation's entry into World War II in December 1941 delayed their plans.

After the war, the PTC began the extensions. The extension to Valley Forge opened on November 20, 1950, and to the western border on December 26, 1951. Additional extensions increased the turnpike to its present 360 miles (579 kilometers).

The PTC also had to address deficiencies on the original segment. Experience had overtaken the "dream highway." On the original segment, the road and the median were too narrow, some of the curves too sharp, and the facility no longer met evolving design standards. The two-lane tunnels that made the financing possible were a traffic hindrance. The PTC began improving the turnpike in the 1960s, including the addition of tunnels or bypasses to expand the two-lane tunnel sections to four lanes.

Pennsylvania Turnpike Commission

The four-lane turnpike narrowed to two lanes at the Allegheny Mountain tunnel and other tunnels inherited from the South Pennsylvania Railway. The reduction in lanes created a bottleneck whenever traffic was heavy.

These two photographs of the Pennsylvania Turnpike exit at Valley Forge from circa 1954 (left) and 2015 (right) show how development grew around the interchange. *Photos: Pennsylvania Turnpike Commission.*

Elsewhere, States from Maine to Texas adapted the PTC model to build their own turnpikes to meet growing demand. By January 1955, the States had opened 1,239 miles (1,994 kilometers) of turnpikes at an investment of $1.55 billion. In addition, 1,382 miles (2,224 kilometers) of toll roads were under construction ($2.3 billion), while plans or studies were underway for an additional 3,314 miles (5,333 kilometers) ($3.75 billion).

Because most of the turnpikes were in corridors identified for interstate highways, Congress had to decide what to do about them before passing the Federal-Aid Highway Act of 1956 to launch the toll-free interstate system that had begun so humbly in that 1939 report to Congress. Congress decided to incorporate the turnpikes and let them carry interstate numbers and shields. That option was preferable to spending billions of dollars to retire the bonds so the roads could become toll-free or to build parallel toll-free interstate highways. (The historic section of the Pennsylvania Turnpike became part of I–80 South, but was renumbered I–76.)

Enactment of the Federal-Aid Highway Act of 1956 on June 29 brought the toll boom to an end. Some new turnpikes would be built, but States now had an option for financing needed expressways, namely interstate construction funds on a 90-10 Federal-State matching ratio. The new Federal commitment was too good to ignore.

As interstate construction funds came to an end in the 1990s, States again began turning to the toll option to finance major roads, bridges, and tunnels. Many of these new toll facilities met full interstate design standards and were added to the interstate system, at State request. Today, the interstate system includes about 2,900 miles (4,667 kilometers) of turnpikes out of a total of 46,876 miles (75,440 kilometers).

The Next Step in America's Progress

In a brochure issued with the opening of the Pennsylvania Turnpike, Walter Jones predicted: "Super-highways are the next step in America's progress." Citing "far-reaching contributions . . . to our economic and industrial wealth," he wrote, "With great benefits accruing from just one such superhighway, consider what it would mean to the Nation at large if the government undertook a vast program of construction of super-highways, linking heavily populated regions."

Because of World War II and other factors, the national superhighway program he imagined was delayed until the 1950s. When the idea began moving to reality, the toll element was dropped, as it had been in 1939, because corridors in less populated areas would not generate enough traffic to retire bonds with toll revenue.

Once launched, what is now called the Dwight D. Eisenhower National System of Interstate and Defense Highways proved just as beneficial as Jones had predicted. It also encountered more controversy than anyone expected, but it's worth recalling Jones' words from 1940: "Many, undoubtedly, will decry any proposed network as being too ambitious and impractical for our day. History will answer such doubts with this admonition: 'You can't stand in the way of progress.'"

Richard F. Weingroff is the information liaison specialist in FHWA's Office of Infrastructure. He also oversees the office's "Highway History" Web site.

For more information on the history of FHWA and transportation, see www.fhwa.dot.gov/infrastructure/history.cfm.

Check Out Your Latest FP

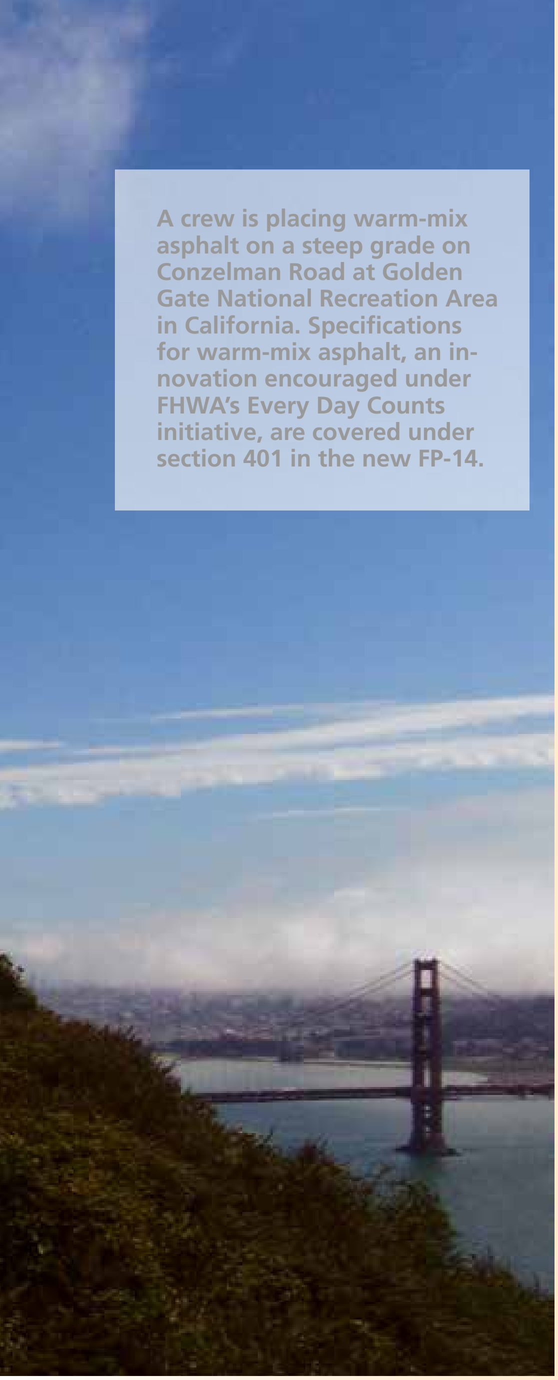
by Charles Luedders and David Green

Every few years, FHWA's Office of Federal Lands Highway updates the specs for building roads and bridges to access Federal and tribal lands. Here's the news.

From the frigid tundra of Alaska to the humid tropics of the Virgin Islands, the Federal Highway Administration's Office of Federal Lands Highway (FLH) designs and constructs roadways within Federal and tribal lands and to access those lands. The need to incorporate practices from all areas of the country and meet the expectations of a wide range of users creates a number of challenges for FLH. To facilitate its work with Federal land management agencies and tribal governments, FLH recently continued its 98-year tradition of providing a nationwide set of standard construction specifications.

As it closed in on its century milestone, FLH published its latest edition of the *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects* (FP) in 2014. Known as the FP-14, the document covers use of construction techniques and materials from all parts of the country, supports FHWA-led innovation programs such as Every Day Counts, and provides a single source to promote the consistency of highway construction across the Nation on Federal lands and even beyond with its use with the Federal Lands Access Program.

The agency issued the new specifications 11 years after its predecessor, the FP-03. Maintaining the FP presents two challenges for FLH: (1) the specifications must allow a wide variety of construction techniques and materials from across the country, and (2) the specifications must be constantly up to date. During the decade in between editions, FLH kept its project specifications current by issuing supplemental specifications. In addition to including those 11 years of innovations in the FP-14, the office developed solutions for addressing the problems associated with updating the FP and created a process to make the next one a less time-consuming task.



A crew is placing warm-mix asphalt on a steep grade on Conzelman Road at Golden Gate National Recreation Area in California. Specifications for warm-mix asphalt, an innovation encouraged under FHWA's Every Day Counts initiative, are covered under section 401 in the new FP-14.

Seth Greenwell, a senior transportation engineer with the National Park Service's Denver Service Center, Transportation Division, who has been involved in projects that used the FP, says, "As it evolves from one edition to the next, the FP has always been a foundation for the projects delivered in support of our Park Roads and Parkways Program. It represents the leading edge of technology and defines the state of the practice for highway and bridge construction." Greenwell cites, for example, the current paving projects in Shenandoah National Park in Virginia, where some of the recent innovations played a crucial role.

A Century of Innovative Specifications

The first FP was a green booklet consisting of 28 pages. This document included an outline of the items to include in a construction contract, but it did not contain specifications as they are known today. As the parent agency of the Bureau of Public Roads, the U.S. Department of Agriculture issued the booklet on April 28, 1917, and, like today, the U.S. Government Printing Office printed it. The Secretary of Agriculture made this new standard effective September 30, 1917.

Over the years, the document grew to the 746 pages contained in today's FP-14. The content of the specifications also have changed. The 1917 version provided only the format for a construction contract. This bare-bones edition progressed to include very prescriptive specifications for contracting methods. Today, the FP continues to move toward performance-based specifications.

Two anomalies over the 98 years were the FP-74 and FP-85 versions, which were produced in Spanish for work in Spanish-speaking territories such as Puerto Rico. Spanish editions are no longer produced due to the cost of printing an additional version.

Responsibility for the FP

The Office of Federal Lands Highway oversees the Federal Lands Transportation Program from its headquarters in Washington, DC, and three geographic division offices develop and administer FLH construction projects. The Western Federal Lands Highway Division in Vancouver, WA, oversees projects in the Pacific Northwest and Alaska; the Central Federal Lands Highway Division in Lakewood, CO, manages projects in the rest of the western States and Hawaii; and the Eastern Federal Lands Highway Division in Sterling, VA, administers projects in the eastern States, Puerto Rico, and the Virgin Islands. An FLH specification coordination group is responsible for producing the FP and consists of a representative from each division and headquarters.

The DC office and the three division offices all have discipline teams consisting of individuals from various functional areas. One of the duties of these discipline teams is to provide technical input for FLH specifications. Each section of the FP-14 is assigned to one of the following discipline teams: construction, environment, geotechnical, highway design, hydraulics, materials, pavements, procurement, safety, and structures.

For most of its construction projects, FLH uses the FP-14 as part of a hierarchy of contract documents. At the head of this hierarchy is the Federal Acquisition Regulations (FAR), issued by the U.S. General Services Administration, U.S. Department of Defense, and National Aeronautics and Space Administration. This document codifies the uniform policies and procedures for acquisition by all executive agencies. The next document in the hierarchy is the Transportation

The 13 editions of the FP are shown here, starting with the first version (lower row, far left), published in 1917.

Tim Gabriel

Some of the innovations in the FP-14 edition played a significant role in the repaving of roads, like this curving one in Shenandoah National Park in Virginia.

Acquisition Regulations. It supplements the FAR by addressing specific transportation issues. The FP-14 supplements these regulations but does not amend them.

Next in precedence come the special contract requirements and then the plans, which supplement and amend the FP-14. The relevant division office develops special contract requirements and plans specifically for each project, and the FP is in place for general control of the work. The FP-14 is at the bottom of the hierarchy of nonspecific contract documents, but it serves as the governing contract document when not changed by special contract requirements or plans.

How the FP Works

The FP is divided into the following 10 divisions or categories of work:

- *Division 100*: General contract requirements, such as measurement and payment. The requirements contained in Division 100 are applicable to all contracts.
- *Division 150*: Project contract requirements, such as mobilization, that are applicable to all contracts and may be paid for directly or indirectly.
- *Division 200*: Earthwork construction requirements.
- *Division 250*: Slope reinforcement and retaining wall requirements.
- *Division 300*: Aggregate and base course requirements.
- *Division 400*: Asphalt pavement and surface treatment requirements.
- *Division 500*: Rigid pavement requirements.
- *Division 550*: Bridge requirements.
- *Division 600*: Incidental construction requirements not covered in the previous sections.
- *Division 700*: Material requirements for divisions 150 through 600.

Taken together, these 10 categories provide a general description of the labor, materials, equipment, and incidentals necessary to construct a roadway or bridge anywhere in the country when used by the Federal agency administering the project.

Because the construction world never stands still and nothing can cover every detailed aspect of future construction, FLH uses three other types of specifications to supplement and amend the FP. These include FLH supplemental specifications, division supplemental specifications, and unique project specifications.

FLH supplemental specifications are additions and revisions to the FP recommended by the specification coordination group and approved by FLH for use on all of its projects. Division supplemental specifications are additions and revisions to the FP or FLH supplemental specifications approved by an FLH division for use on that division's projects. Unique project specifications are additions and revisions to the contract documents used to address unique requirements of a specific project.

Each FLH division maintains a library of specifications that includes these supplements and amendments to the FP. For each contract, the FLH division includes the applicable specifications from its library and writes the unique project-specific specifications

Growth in Number of Pages in the FP

Source: FHWA.

to produce the project's special contract requirements, which become part of that contract.

Updating the FP

FLH does not have a set timetable for publishing a new FP, because external factors—such as the requirement for adding metric specifications—often dictate the time between publications. In the past, FLH has published new FPs in as short a timespan as 4 years and as long as 18 years. The average is 8.1 years between publications, with a median timespan of 6.5 years.

In theory, updating the FP should be a continuous process. With innovations constantly affecting construction, the specifications must keep pace with new equipment, new processes, and enhanced materials.

Within FLH, the specification coordination group oversees a process for developing specifications. The group receives proposed FP changes from the FLH divisions, the FLH discipline teams, other employees, contractors, material suppliers, and Federal and tribal partners. The specification coordination group then reviews the proposed changes, in cooperation with the applicable discipline team, and conducts an FLH multidisciplinary review.

Based on the results of this review, the group recommends one of three dispositions for the proposed change: (1) The specification coordination group adopts the change as an editorial improvement for the FP and inserts it into the draft for the next FP. (2) The group recommends the proposed change for adoption as an FLH supplemental specification; in which case, if approved, it is adopted for immediate use on FLH contracts and is inserted into each division's library of specifications and the draft for the next FP. (3) The group rejects the proposed change; in which case, a division can use it as a supplemental specification or as a unique project specification.

Theoretically, the next FP should be the marked-up draft of the current FP generated through this specification development process.

However, past experience shows that an announcement to publish a new FP is required to initiate the desired focus on specifications within FLH. With such an announcement, FLH divisions conduct internal reviews and submit proposed changes for the new FP. The FLH discipline teams review the FP sections for which they are responsible and often submit complete rewrites. Contractors, material suppliers, and Federal and tribal partners also submit their desired changes. Often, the submissions are received at or after the deadline. All of these last-minute proposals for changes can overwhelm the process for developing specifications and result in major delays in publishing a new FP.

Once all of the change proposals are reviewed and responded to and an FLH internal draft of the next FP is reviewed, a draft is prepared for review by other FHWA offices and outside the agency. Comments are solicited from the American Association of State Highway and Transportation Officials, American Road & Transportation Builders Association, Associated General Contractors of America, and other Federal and tribal partner agencies.

For the FP-14, these outside agencies submitted few comments, but reviewers within FLH generated an overwhelming number. After the discipline teams and the specification coordinating group addressed these comments and an editorial review was completed, the FP-14 was published 2 years behind the original schedule.

Innovations Included In the FP-14

The FP incorporates innovations from the road and bridge construction industry. This process takes time, as most innovations begin as supplemental specifications and are incorporated into the FP only after they become mainstream. A review of specifications included in FP-14 that did not appear in FP-03 provides examples of innovations and reveals the time it takes for innovations to move through this process.

Section 252 of FP-14 includes rockeries for the first time. Rockeries are an engineered system of dry, stacked, angular rocks placed without mortar, concrete, or steel reinforcement. This technology dates back to historic dry stacked walls but adds an engineered aspect to the design and construction of these slope support systems. Rockeries are visible today on many projects in mountainous terrain due to their aesthetic characteristics and use of standard construction equipment and onsite material.

Section 257, contractor-designed retaining walls, is an innovation that illustrates the movement toward performance specifications. Instead of detailing the retaining wall to be constructed, this specification allows the contractor to design and construct the type of wall most suited to the firm's

Work is underway here to reestablish turf at Guanella Pass in Colorado, an effort that resulted in an environmental award for the project. Information about reestablishing turf and relocating native plants is in section 625 in the FP-14.

Crews constructed this roundabout at Golden Gate National Recreation Area in California, a project covered under sections 401 and 609 of the FP-14. Roundabouts are a traffic management system that can help reduce vehicle conflicts and fuel consumption.

knowledge and equipment, as long as the wall meets certain design parameters for retaining walls. This flexibility essentially enables the contractor to value-engineer the retaining wall, minimizing costs.

Sections 304 through 306 add several processes for full-depth pavement reclamation. These processes allow paving crews to mill the existing pavement and incorporate that material into a new base course. Reusing the entire existing pavement reduces transportation costs and eliminates wasted materials. This approach contributes to FHWA's goals of reducing greenhouse gases and accelerating construction of new roadways.

Section 409, microsurfacing, reflects the addition of preservation and maintenance activities as eligible for Federal-aid funding. This innovation, used in the United States since the 1980s, provides another technique in the toolbox for extending the life of existing pavements.

Structural innovations that appear in the FP-14 include concrete injection and high-performance concrete. These specifications reflect advancements in materials related to the concrete industry. Section 561, structural concrete injection and crack repair, is made possible by low-viscosity epoxies capable of penetrating the narrowest of cracks and providing excellent bonding capabilities. Section 568, high-performance concrete, is made possible by advances in admixtures and other enhancements that make better use of cement particles, reduce permeability, and increase the strength and durability of concrete.

Section 708, plastic pipe, illustrates the evolution of innovations and how construction materials and methods change over the years. The FP-74 included section 706 for concrete, clay, and fiber pipe. This change evolved into concrete, clay, plastic, and fiber pipe in the FP-79, which continued through the FP-85. The FP-92 changed this section to concrete and plastic pipe, dropping the specifications for clay and fiber pipe. This designation continued through FP-03 until FP-14, in which plastic pipe receives its own section.

Innovation in Writing Specifications

Innovation and change also affect specification writing. Most older specifications were method specifications. That is, the specification writer tried to ensure quality by telling the contractor how to construct something, and an inspector was charged with ensuring that the item was built according to the specification. This approach placed responsibility for quality control on FLH.

The FP-14 progresses away from method specifications toward performance specifications. A performance specification provides parameters for the end product that the contractor must meet and measures used to verify the contractor's performance. The methods and many material issues are left to the contractor's discretion, and the contractor assumes the responsibility for quality control.

Performance specifications led to the use of statistical acceptance. Statistical acceptance first appeared in the FP-85 and relied on the premise that a bell curve represents the distribution of sample populations. Using statistical concepts, FLH calculates the percentage of material within the established limits. This information enables FLH to provide a bonus to the contractor for constructing superior work and to penalize or reject the contractor's work when it does not conform to the specification. The FP-14 continues the progression toward statistical acceptance.

Making specifications easier to interpret is an ongoing process.

FLH started incorporating the concepts presented in National Highway Institute course 134001, Principles of Writing Highway Construction Specifications, in the FP-92. The objective was to make the FP conform to the five C's of specification writing: clear, concise, complete, correct, and consistent.

The need to promote this objective throughout FLH led to the publication of two additional documents in 2008. *Specification Writers' Guide for Federal Lands Highway* (FHWA-CFL/TD-08-001) addresses specification writing style, organization and format, proper terminology and phrasing, capitalization and abbreviation, and punctuation and grammar. *Federal Lands Highway Specification Procedures* documents the procedures FLH uses to develop and maintain specifications, including the FP. Both of these documents are being updated to incorporate lessons learned from the FP-14.

The FP-92 also initiated the use of active voice and imperative mood with the subject—the contractor—being implied. Efforts continue to make the FP understandable at an elementary grade level. Sentences are intentionally kept short, and tables and lists are used extensively to convey the message. The goal is to deliver each message once, so the subsections on acceptance generally send the reader to section 106, which concerns the requirements for acceptance, whether they be visual, by certification, or by testing. The subsections for measurement and payment send the reader to section 109, which focuses on the methods and units of measurement, along with the units of payment.

Another FP-14 change is the adoption of dual units. FLH produced U.S. customary and metric versions of the FP-03. This required the publication of two books. The FP-14 combines this effort into one book, providing U.S. customary units followed by metric units in parentheses.

Innovation and changing work types have another outcome. Some specifications disappeared from the FP-14. Items removed since the FP-03 include crib walls, previously in section 254, and cutback asphalt, in subsection 702.02. Mechanically stabilized earth walls and other wall types replaced the need for crib walls, which require more material and are more expensive to construct. Cutback asphalt disappeared because of its use of solvents that evaporate and are detrimental to the environment. Emulsified asphalt, using water as the workability agent, replaces cutbacks.

How To Obtain the FP-14 And Related Publications

Electronic copies of the FP-14, *Specification Writers' Guide for Federal Lands Highway*, and *Federal Lands Highway Specification Procedures* are available at http://flh.fhwa.dot.gov/resources/pse/specs. Multiple paper copies of the FP-14 (GPO Stock Number 050-001-00346-5, ISBN 9780160923937) are available from the Government Printing Office at http://bookstore.gpo.gov/products/sku/050-001-00346-5. To receive a single paper copy of the FP-14, contact the U.S. Department of Transportation's Research and Technology Product Distribution Center by email at report.center@dot.gov, phone 814–239–1160, or fax 814–239–2156.

Future Vision for the FP

Producing the FP-14 took nearly 6 years. The involvement of the discipline teams and a renewed push for the five C's resulted in major changes and rewrites of many of the FP-14 sections. FLH's goal is to use the development process to update specifications continually. This process should help to avoid some of the delays associated with the FP-14 and should maintain a current draft of the next FP that can be published with minimal effort.

But is another printed version of the FP required? An electronic copy of the FP-14 is available online, and each FLH division maintains an electronic library with all updated supplemental specifications. FLH is continuing the move to e-Construction, and the use of electronic specifications is most likely the future. The U.S. Government Printing Office kept only 350 copies of the FP-14 for its sales inventory, with a total production run of 12,000 copies that were shipped to FHWA and other agencies. The future may see FLH providing electronic specifications and contracts that list specifications and their versions, just like Federal Acquisition Regulations clauses are inserted in today's contracts. The FP-14 just might be the last printed copy of a document that started with humble beginnings back in 1917.

An FP You Can Use

The FP-14 provides a source of information on road and bridge construction for anywhere in the country. It draws upon specifications refined and matured over nearly 100 years.

The FP-14 resource is available to all who have an interest in the construction of roads and bridges on Federal lands or providing access to those lands. Other sources include the specifications used by the 50 State departments of transportation.

"FP-14 gives Federal Lands [Highway] a resource to manage construction work as diverse as an interchange on the George Washington Memorial Parkway [in northern Virginia] to a boardwalk for a subsistence village in Alaska," says Bob Arnold, acting associate administrator of Federal Lands Highway. "It is a valuable tool for us."

Charles Luedders, P.E., is the special assistant to the associate administrator of FHWA's Office of Federal Lands Highway. Luedders serves in an advisement capacity, performs reviews of critical issues, and provides administrative support. He has a B.S. in civil engineering from the University of Nebraska.

David Green, P.E., was the construction standards engineer in FLH in Washington, DC, for 26 years and was responsible for maintaining and publishing the FP-92, FP-96, FP-03, and FP-14. He retired in 1999, but continued this work on a reemployed part-time basis until his full-time retirement in 2015. He holds a B.S. in forestry from Pennsylvania State University.

For more information, contact Charles Luedders at 202-366-9631 or charles.luedders@dot.gov.

Powering an Energy Revolution

by Leslie Myers McCarthy, Seri Park, and Anthony R. Giancola

A boom in U.S. energy development is challenging transportation agencies to alleviate the strain related to increased truck traffic on aging infrastructure.

A truck transporting a load of oil field storage tanks struck this overpass bridge on I–10 in Pecos County, TX, about 8 miles (12.8 kilometers) east of Bakersfield. Impacts, such as bridge strikes, to roadway infrastructure from activities related to energy development are the focus of the NCHRP Synthesis 469. *Photo: Texas Department of Transportation.*

For the first time in 40 years, the United States has achieved relative energy independence. Emerging and evolving energy development in the United States has become a bright spot in the national economy and has created opportunities for both skilled and unskilled labor.

While energy independence is good news, the expansion of these industries has implications for transportation infrastructure. For example, geographic shifts in oil and gas extraction have led to greatly expanded transport of oil by truck and rail. In many cases, expansion involves movement of heavy equipment and other supplies to rural locations and puts pressure on a functional class of roads and bridges that were not constructed to handle the heavy loads associated with expansion and increased traffic.

The U.S. Energy Information Administration reports that the variety and magnitude of energy development is either expanding or holding steady—a trend that is likely to continue. Transportation agencies are rising to the challenge to address the increased demand on the highway infrastructure and damage resulting from traffic related to energy development. Agencies that are responsible for transportation infrastructure are requiring surety instruments (a promise by one party to assume responsibility for the debt obligation of a borrower if that borrower defaults), permits, bonds, and excess maintenance agreements from energy companies. Some transportation agencies and infrastructure owners also are strengthening roads and bridges to carry the increased loads. In many areas, agencies also are addressing potential safety concerns from increased truck traffic. For the most current information and trends in energy development, visit the Web site of the Energy Information Administration at www.eia.gov.

The Effects on Roads and Bridges

Published by the National Cooperative Highway Research Program, *Synthesis 469: Impacts of Energy Developments on U.S. Roads and Bridges* documents the impacts of the energy sector on the transportation system and state-of-the-practice strategies to minimize damage. The report aims to help Federal, State, tribal, and local transportation managers better understand and communicate the negative impacts of energy development on roads and bridges, while also selecting appropriate strategies to manage them.

In addition to examining road damage from energy development, Synthesis 469 reports on the economic costs associated with supporting energy development. The report provides energy companies with the tools to assess the costs and help pay for infrastructure damage. The synthesis also looks at current design standards and engineering methods to address the increased frequency and weights of heavy truck traffic, practices used to address the safety implications of increased vehicle volumes, and examples of agency and industry collaboration to address roadway issues.

In addition, the synthesis discusses the efforts of departments of transportation in 40 States plus the District of Columbia, and related local public agencies to mitigate the effects of energy development, and provides examples of alternative options to manage those impacts more effectively. It also reviews engineering practices, funding approaches, and contractual mechanisms for dealing with the effects of energy development.

Roadway Deterioration

The most visible effect is the deterioration of paved and unpaved roads. When surveyed for Synthesis 469 in early 2014, 27 State DOTs indicated that they observed an increase in the amount of truck traffic volumes and heavy loads in recent years.

"Increased traffic volumes, particularly heavy trucks, have accelerated the deterioration of State highways in the oil-impacted areas," says Ron Henke, P.E., deputy director of engineering at the North Dakota DOT. "Roadways in the western part of the State were originally built to handle agriculture traffic, small grains and ranching, and were not built to carry the heavy loads associated with oil development." As a result, Henke says, "Design life on some roads in western North Dakota has been reached in a shorter amount of time [than estimated in the original design]."

He continues, "For example, U.S. Highway 2, which is a major corridor in western North Dakota, reached [the end of] its design life in 8 years rather than the [projected 20- to 30-year design life]."

State DOTs reported that secondary roadways are the most affected

Number of States Producing Various Types of Energy

Energy Sector	Number of States
Biofuels	47
Coal	25
Natural Gas	33
Nuclear	31
Oil	31
Solar	23
Wind	39

Source: Leslie Myers McCarthy, Villanova University. Adapted from U.S. Energy Mapping System, U.S. Energy Information Administration, 2013.

by truck traffic. In fact, 10 States noted a significant level of impact on local roads, while 7 States reported a significant level also for minor arterials or collectors and distributors. More than half of the respondent DOTs rated the impact on minor arterials and local roads at a moderate level. Interstates or freeways were the least affected.

According to Brian Roberts, executive director of the National Association of County Engineers, "The negative impact and accelerated deterioration on local roads in rural areas is significant, requiring increased levels of repair and maintenance and severely impacting the budgets of local jurisdictions."

The damage attributable to heavy vehicles is difficult to quantify in rural areas, but some State DOTs, such as those in Arkansas, New Jersey, North Dakota, and Texas, are investigating ways to do this. The most common measure used to quantify damage is remaining service life for pavements and structural analysis for bridges. Synthesis 469 showed that the reduction in service life for pavements was up to 30 percent in some cases.

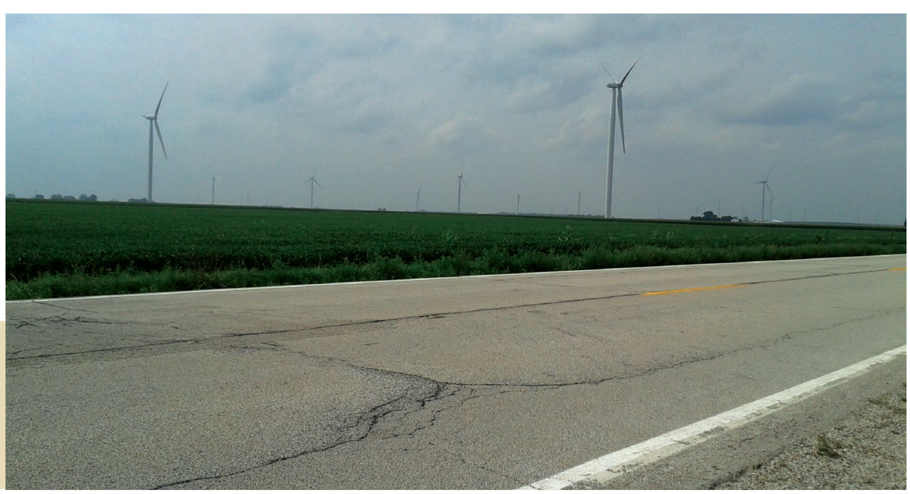
Damage to Bridges

Local bridges are also vulnerable to damage from increased truck traffic and heavy loads. Some overheight trucks have struck bridges, requiring closures and expensive repairs. Other safety concerns relate to the thousands of bridges that do not have adequate width to accommodate drilling rigs and other oversized loads, along with the necessary structural capacity to handle increased volumes of heavy trucks.

Recently, national media reports have covered the need for repairing thousands of bridges, even without the addition of energy-related truck traffic. In 2013, an Associated Press analysis of 607,380 bridges in the National Bridge Inventory showed that 65,605 were classified as "structurally deficient."

The Texas DOT reports increased volumes of heavy trucks (typically 40–60 tons, 36–54 metric tons), particularly on narrow bridges, and truck mirrors striking as they pass each other. Other narrow roadways have experienced an increase in crashes, run-off-road incidents, and fatalities.

The Yoakum region of Texas (not far from San Antonio), a mostly rural area with significant energy development and nearly 4,000 bridges, has had multiple bridge collapses and crashes related to the width and height of bridges. Narrow, one-lane bridges require drivers to wait until a truck or other vehicle has crossed completely in order to advance. Communities in the region have complained about trucks on the bridges, and in response, TxDOT has increased signage that warns drivers about narrow bridges.



The flexible pavement on this county road near Gifford, IL, shows signs of distress (visible cracking). The road services the adjacent wind farms visible in the distance.

Leslie McCarthy

Scott Babcock

These unpaved gravel roads in the vicinity of oil pad well sites in Lycoming County, PA, show deterioration and rutting along the shoulders.

Funding Repairs And Improvements

Synthesis 469 shows the costs to DOTs to provide energy development companies with adequately performing roadway and bridge infrastructure. The synthesis also shows significant costs to energy developers from user delays that result from work zones necessitated by repairs to infrastructure and longer haul times because of detours. Duke University found that to support shale energy development, in a number of States, roadway costs have increased faster than the revenues from energy development.

Compensation paid from energy developers to States or local agencies includes fees for development impacts based on the magnitude of the developments or user fees based on measured damage to specific roads. Some States also set up donation agreements with energy developers; use energy-related permit fees; apply severance, property, production, or sales taxes; use lease revenues; and implement maintenance agreements.

State DOTs also are repairing damage with a combination of State and local funding. When surveyed, only six DOTs reported that they have established agreements with energy companies to pay for repairs.

Safety Concerns

The Upper Great Plains Transportation Institute reports that western North Dakota was continuing to experience an economic boom because of energy industry expansion in 2013. The institute also found that unanticipated traffic safety issues are occurring on roads originally designed for local access and agricultural purposes, because they are carrying high truck volumes to serve the expanding oil sector. In fact, the number of crashes in approximately half of the counties (in a 17-county area affiliated with oil production) is above the State average for crash risk, considering all crash types on rural roads.

The study team for Synthesis 469 identified North Dakota and Texas, as well as Colorado, Iowa, and Pennsylvania, for more detailed interviews based on their geographic distribution, level of growth in energy development, types of energy product transported, level of observed infrastructure and safety impacts, and methods used for quantifying the economic effects of energy development.

Based on these detailed interviews, as well as the surveys and literature reviews, the synthesis highlights effects on road systems observed by agencies and how they are addressing them. It presents effective practices such as techniques for meeting design challenges, tools to assess costs, use of contractual agreements, and methods to mitigate negative impacts on safety.

Strategies for Pavements

The most common method for assessing the effect on paved roads is by determining the remaining service life of the pavement. Road owners can compare the remaining service life to the predicted service life under typical conditions. Data inputs for computing a pavement's remaining service life include portable and virtual weigh-in-motion devices for identifying traffic volumes and load levels, falling weight deflectometer and ground-penetrating radar for determining the structural capacity of pavement layers, and the automated road analyzer for collecting geographically related information on pavement condition.

Roadway repair methods include stabilization of unpaved roads, use of full-depth reclamation of existing pavements, addition of paved shoulders, and strengthening of gravel or dirt roads with geosynthetics. What follows are two examples of how State agencies are addressing the effects on paved roads.

In 2010, North Dakota State University reported that load limits are

Safety and Congestion

The U.S. Department of Transportation reports that the increased number of large trucks involved in fatal crashes, injury crashes, and property damage only crashes in areas where energy development is occurring has created a number of new safety concerns. In the Synthesis 469 survey, 19 States reported an increase in conflicts with local traffic (such as school buses, regional transit, and agricultural and husbandry vehicles) by heavy vehicles supporting energy development. Twelve States noted that the congestion level on public roads with heavy truck volumes could be attributed primarily to roadway geometric and vertical clearance issues. Congestion on adjacent roads and conflicts with infrastructure (vertical clearance issues) were reported as other noticeable congestion patterns.

Measures for agencies to address safety and congestion concerns include using detours and alternate routes, increasing the heavy truck warning signage, use of advance warning intelligent transportation systems, or adjusting the timing and logistics of truck movement schedules.

Revenue Sources and Costs for Local Governments in States with Shale Energy Development

State	Major Revenue Source(s)	Major Costs	Net Fiscal Impact
Arkansas	Property taxes, in-kind contributions (road repairs)	Roads	Medium to large net positive
Colorado	Property taxes, severance tax revenue, in-kind contributions (road repairs)	Roads, staff costs	Small net negative to large net positive
Louisiana	Lease revenue, sales tax	Roads, staff costs	Medium to large net positive
Montana	Severance tax revenue	Roads, staff costs	[insufficient data]
North Dakota	Severance tax distributions, sales tax	Roads, staff costs	Small to medium net negative
Pennsylvania	Act 13 distributions	Staff costs	Small to large net positive
Texas	Property taxes	Roads, staff costs	Neutral to large net positive
Wyoming	Property taxes, sales tax	Roads, staff costs	Large net positive

Source: Leslie Myers McCarthy, Villanova University. Adapted from Shale Public Finance: Local government revenues and costs associated with oil and gas development, *Duke University Energy Initiative, May 2014. Note: Pennsylvania Major Revenue: In 2012, Pennsylvania enacted legislation, Act 13, which imposes an "impact fee" on each new unconventional gas well drilled in the State.*

necessary during spring thaws when the modulus of some soils increases the relative damage from heavy truckloads by up to 400 percent. Spring load restrictions typically lasted 6 to 8 weeks, depending on the soil conditions. To help predict when truck restrictions should be enforced, the North Dakota DOT has developed a predictive model for use in the western part of the State. The model could be adaptable for use by other States and Canadian provinces. In addition, according to North Dakota DOT's Henke, "North Dakota DOT has worked with local officials in some communities to build truck bypasses or truck reliever routes around the cities to help alleviate truck traffic through the communities."

In Texas, an ongoing study by the Texas A&M Transportation Institute (TTI) is evaluating practices used by DOT maintenance personnel, both routine maintenance activities such as patching and nonroutine reconstruction tasks such as strengthening roadways, chip seals, and new base layer materials. The study also focuses on pavement design—including the cross-sectional width, layer thickness, and shoulder materials and widths—for affected farm-to-market roads.

During the study, TTI is testing whether expanding the width would benefit these roadways because their current narrow footprints are unable to handle the size and loadings of the trucks. Texas intends to widen horizontal curves and enhance vertical curve drainage to accommodate larger trucks more safely. The researchers are using a decision tree to tie together pavement performance and life-cycle costs in order to monitor repairs and rehabilitation strategies.

"Four workshops and a series of energy sector technical reports and briefs were generated from the research collaboration between TxDOT and TTI," says Jon Epps, executive associate director of TTI. "These workshops and supporting documents will help ensure that the current state-of-the-practice guidelines are being utilized to repair damaged roadways. For instance, the technical briefs provide information on pavement analyses, which will [enable] district engineers to determine recommended roadway shoulder widths, as well as shoulder/edge repair techniques."

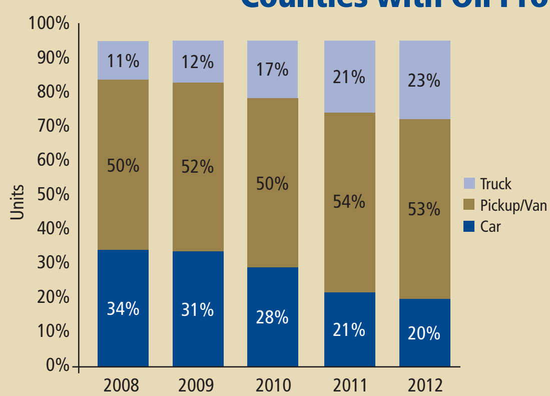
Strategies for Bridges

A standard practice in most States is that if a bridge is unable to withstand the legal load limit, then the State DOT posts weight limits. If equipment going to or coming from the oil fields is overweight, the energy company can request a permit to run oversize or overweight loads on the roads. However, even with a permit, oversize or overweight trucks may not cross a posted bridge.

The issue of overheight trucks has been particularly prevalent in Texas. In 2014, Texas experienced 23 bridge hits statewide. TxDOT launched a publicity campaign to remind drivers about overpass height restrictions. The campaign included distributing pamphlets at truck stops, broadcasting by radio, and printing billboards in both English and Spanish. Other strategies that TxDOT uses include signing all bridges with heights under 18 feet (5.5 meters), as well as accelerating construction projects to raise the elevations within 6 to 12 months to accommodate energy activities.

In Pennsylvania, energy companies have used temporary "jumper" bridges to bypass the permitting process for oversize (excluding overheight, if height restrictions exist) and overweight loads, and to manage heavy truck traffic. The practice involves constructing temporary, modular superstructures over existing bridge decks to carry the heavy loads. The jumper bridges then are dismantled when

Crashes by Vehicle Type in North Dakota Counties with Oil Production



In approximately half of the 17 counties associated with oil production in North Dakota, the number of crashes is above the State average. This graph shows the increase in percentage of crashes involving trucks between 2008 and 2012 (11 percent and 23 percent, respectively).
Source: Upper Great Plains Transportation Institute, 2013.

Leslie McCarthy

This truck is carrying a heavy load on Route 136 through soybeans and cornfields near Gifford, IL. The shoulder shows visible rutting and load-related cracking.

the energy companies no longer need them. Energy companies used this practice to support drilling activities in Lycoming County, PA. A later inspection by the county found that the roadways underneath the jumper bridge were relatively undamaged because the temporary structures carried the loads.

Costs and Funding

To assess costs and pay for damages, States use a number of strategies. Among the most common are (1) identifying accurate truck volumes and their associated payloads; (2) using a variety of taxes, fees, adequate public facility ordinances, and other reimbursement mechanisms; and (3) applying the truck traffic percentage or the vehicle-miles traveled as a factor for use in a cost formula. Many States cited an increase in applications for oversize and overweight vehicle permits, along with more frequent requirements for roadway or bridge maintenance, as the basis for developing a cost formula.

State DOTs are repairing roads and bridges with a combination of State and local funding. Several DOTs—Arkansas, Iowa, Pennsylvania, Utah, and West Virginia—share a percentage of costs between their agencies and the energy companies, and have found this strategy to be effective. The DOT in Iowa indicated that energy development companies cover 100 percent of the costs for roadway and bridge repairs. In Pennsylvania, energy companies pay 100 percent of the repair costs in many cases, and the DOT and energy companies share costs in other cases. Both Arkansas and Utah DOTs cost-share at 75 percent to the agency and 25 percent to the energy company. West Virginia DOT reports a cost-sharing split at 25 percent by the agency and 75 percent by the energy company.

The Minnesota DOT uses an Excel®-based cost calculator that enables users to estimate potential damage to pavements on local roads during the heavy construction traffic associated with wind turbine developments. The calculator is available for download at www.dot.state.mn.us/research/documents/trafficgenerator.xls. Users also can estimate costs to repair or reconstruct affected roadways.

The United States Forest Service's model for funding requires energy developers to purchase road use permits. This process regulates access to forest roads by the developers, provides flexibility to modify permits for specific situations, and requires energy companies to improve and maintain the condition of existing forest roads to standard before and during use for energy development activities.

Financing Legislation

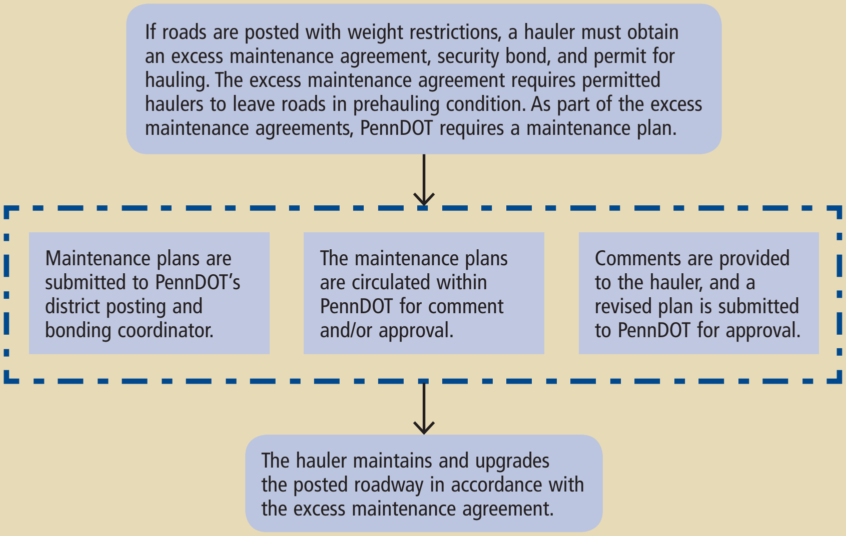
The Pennsylvania Department of Transportation (PennDOT) and local agencies in Pennsylvania frequently communicate and partner with energy development companies to minimize the amount of roadway damage caused by heavy trucks. PennDOT posts weight restrictions and uses agreements with energy development companies for roadway maintenance. The companies are required to submit an annual roadway maintenance plan. The plan must detail how the companies will repair damages when they occur and who they will contact to evaluate and complete the work.

In addition, Pennsylvania Act 89 legislation requires user fees to establish a funding source for transportation needs and assists in addressing the backlog of roads and bridges that need repairs. As part of the comprehensive Pennsylvania Act 13 legislation passed in 2012, an impact fee on energy companies was levied based on the level of drilling activity. The Pennsylvania Utility Commission collects fees, which it then distributes to municipalities and Commonwealth of Pennsylvania programs. For

Potential Mitigation Techniques

- Long-life flexible, rigid, or composite pavement designs.
- Asphalt or concrete mixture designs that resist heavy loads.
- Predetermined alternate routing for trucks based on structural condition ratings or inspection data.
- Temporary structural monitoring (sensors) on the most vulnerable bridges, culverts, or other structures.
- Use of intelligent transportation systems for advance warning systems, such as curve warning, real-time traffic congestion, and traffic incidents.
- Tagging of energy developer transport vehicles with GPS transponders.
- Increased use of signage to warn motorists of heavy truck traffic volumes.
- Collaboration with energy development companies to adjust the timing and logistics of truck movements (for example, a staged truck routing schedule).
- Media safety campaigns and increased enforcement.

Key Steps for Roadway Maintenance Plans in Pennsylvania



Source: Leslie McCarthy.

example, Lycoming County and its 52 local municipalities collectively received approximately $25 million from Pennsylvania Act 13 funds.

Pennsylvania is the only State that reported having such legislation in place during the Synthesis 469 survey. However, other States reported having similar legislation in the works.

The Path Forward

A clearer path forward is taking shape to balance the competing outcomes of energy development. However, agencies must recognize that energy extraction and production technologies are continually evolving and, as a result, some practices may not continue to be effective. To ensure the most effective practices, agencies should conduct periodic joint reviews with energy companies. Agencies also should consult periodically with freight planning offices in metropolitan and regional planning organizations. Monitoring the larger freight-planning picture will help agencies to recognize current or projected shifts in the transport of energy by rail, pipelines, or motor carriers.

Future data collection should consider the existence of adequate staff resources, efficient methods for comprehensive analyses of crash data, and use of available electronic databases. Agencies should review the contribution levels of energy companies, in terms of their size, to fund repairs and uphold maintenance agreements. Although many large companies contribute a share of the funding commensurate to the repairs required for roads and bridges, the industry does not yet know whether the same level is possible with smaller independent energy companies.

Additional areas of consideration may include the integration of transportation planning techniques with energy industry mapping of future development, the collection of safety and crash statistics on affected rural roads, improved methods for pavement and geometric design of affected rural roads, and engineering-based methods for detour routing during periods of high-activity energy development.

Synthesis 469 concludes with an analysis of research needs, such as quantitative information on the specific economic, safety, and social impacts of energy development activities on secondary roads. A clear need exists for research on predicting reductions to the service life of roads and bridges. In addition, a need exists to better quantify the extent of damage induced on more heavily traveled roadways such as freeways, interstates, and major arterials, particularly in areas near port facilities or where modal shifts are occurring. Synthesis 469 also recommends researching performance metrics to monitor quantitatively the effectiveness of practices addressing the various issues related to energy development in a given State or region.

Lastly, to gain a more complete picture of energy development and the impacts on State and local roadway infrastructure, State DOTs should consider input from other State agencies that manage activities such as economic development, public safety, and motor vehicle registration.

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For more information, see http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_469.pdf or contact Leslie McCarthy at 610-813-2083 or leslie.mccarthy@villanova.edu.

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.

Management and Administration

Secretary Foxx Signs Memorandum Of Cooperation with India

In April 2015, Secretary of Transportation Anthony Foxx traveled to Delhi, India, to sign a memorandum of cooperation on transportation with India's Minister Nitin Gadkari, who oversees the Ministry of Road Transport and Highways and Ministry of Shipping. The memorandum establishes a transportation partnership between USDOT and the Indian Ministries of Railways, Road Transport and Highways, Shipping, and Urban Development.

The National Highway Traffic Safety Administration has been working with the Ministry of Road Transport and Highways on road safety programs, including drunk driving countermeasures and motorcycle safety. The memorandum also will deepen the level of cooperation between the two countries to include new activities relating to the development of sustainable and smart cities—communities that are prepared for population growth and a more volatile climate, and that provide high-quality public transportation systems that connect their residents to jobs and other opportunities.

Cooperation on the transportation elements of smart cities will be coordinated through an interministerial working group and include areas such as intelligent transportation systems, multimodal planning, livability, safety, and infrastructure financing. In addition, both countries agree to cooperate on standards of vehicle fuel efficiency and promote dedicated freight corridors to facilitate the movement of goods from India's ports to its major cities.

While in India, Secretary Foxx also met with representatives from U.S. and Indian transportation companies to discuss the development of advanced technologies and to help resolve market access issues that will facilitate trade between the two countries.

NHTSA Forms New Safety Teams

USDOT recently released two internal reports from NHTSA that outline the changes the agency has adopted to strengthen its workforce dedicated to investigating vehicle defects. In June 2015, Secretary Foxx announced the formation of a three-person Safety Systems Team of outside experts who will spend 1 year advising NHTSA on implementing the changes outlined in the reports.

NHTSA's Safety Systems Team will guide and validate strategy, tactics, and actions to enhance the agency's effectiveness. The team includes Joseph Kolly, director of the Office of Research and Engineering at the National Transportation Safety Board, who is detailed to NHTSA for the remainder of 2015. He is joined by J. Victor Lebacqz, former associate administrator for aeronautics research at the National Aeronautics and Space Administration (NASA), and James P. Bagian, director of the Center for Healthcare Engineering and Patient Safety at the University of Michigan. Bagian is a professor at the University of Michigan's medical and engineering schools and is a former NASA astronaut and veteran of two space shuttle missions.

NHTSA also launched an internal Risk Control Innovations Program that will bring together NHTSA staff involved in vehicle safety, behavioral safety, and enforcement to address emerging highway safety risks that cut across the agency. The program's multidisciplinary teams will develop individualized solutions to problems that fall outside the agency's specialized programs.

For more information, visit www.nhtsa.gov/About+NHTSA/Press+Releases/nhtsa-forming-new-safety-teams.

NHTSA

Policy and Legislation

New Requirement May Prevent Nearly 1,800 Crashes Annually

NHTSA recently finalized a rule requiring electronic stability control systems on heavy trucks and large buses (FMVSS No. 136). Electronic stability control works instantly and automatically to maintain directional control in situations where the driver's own steering and braking cannot be accomplished quickly enough to prevent a crash.

The National Transportation Safety Board has recommended a requirement for electronic stability control on heavy-duty vehicles since 2011. The Moving Ahead for Progress in the 21st Century Act, enacted in 2012, directed NHTSA to consider a requirement for electronic stability control in motorcoaches, which are covered in the new rule. A rule requiring light-duty vehicles to include the technology took effect in 2012.

Anatoly Tiplyashin/Shutterstock.com

Heavy-duty trucks like this one will be required to have electronic stability control technology within the next 2 years to improve safety and reduce crashes, injuries, and fatalities.

NHTSA estimates that the rule for heavy trucks and large buses could prevent as many as 1,759 crashes, 649 injuries, and 49 fatalities each year. Further, this technology is estimated to prevent up to 56 percent of untripped, rollover crashes—that is, rollover crashes not caused by striking an obstacle or leaving the road.

The final rule, announced in June 2015, requires electronic stability control systems on heavy trucks and large buses exceeding 26,000 pounds (11,800 kilograms) in gross weight. Most heavy trucks must be in compliance with the rule within 2 years. The requirement will take effect in 3 years for buses larger than 33,000 pounds (15,000 kilograms) and 4 years for those weighing between 26,000 and 33,000 pounds (11,800 and 15,000 kilograms).

NHTSA

Technical News

MPOs Selected for Pilot of Technology To Count Bicyclists and Pedestrians

As part of Secretary Foxx's Mayors' Challenge for Safer People, Safer Streets, the Federal Highway Administration selected 10 metropolitan planning organizations (MPOs) to participate in a pilot program for technology to count bicyclist and pedestrian activity. Award recipients will receive funds to purchase automatic counters that will collect counts at various locations within an MPO planning area during a 1-year period.

FHWA selected MPOs in California, Florida, Indiana, New York, Ohio, Puerto Rico, Rhode Island, Tennessee, Virginia, and Wisconsin. FHWA and the Pedestrian and Bicycle Information Center will provide technical support for each MPO in setting up the counters; uploading, downloading, and analyzing the data; and using the data to improve the planning process in their communities. The pilot program aims to kick-start the development of best practices in counting bicyclists and pedestrians. It aligns with one focus of the Mayors' Challenge: to collect more and better data on pedestrian and bicycling activity to support planning and investment decisions and target safety improvements.

Recipients will provide insights on their experiences and report initial data by December 2015. The projects will be completed in spring 2016.

For more information on the Mayors' Challenge, visit www.transportation.gov/mayors-challenge.

Public Information and Information Exchange

New USDOT Program Bolsters Economic Development

Seven cities will foster sustainable economic development related to planned transportation projects, thanks to a USDOT technical assistance program, the Ladders of Opportunity Transportation Empowerment Program (LadderS^{TEP}). Choices regarding transportation infrastructure at the Federal, State, and local levels can revitalize communities, create pathways to work, and connect communities to a better quality of life. LadderS^{TEP} is part of a broader initiative called Ladders of Opportunity that examines those choices.

The LadderS^{TEP} pilot program will provide Atlanta, GA; Baltimore, MD; Baton Rouge, LA; Charlotte, NC; Indianapolis, IN; Phoenix, AZ; and Richmond, VA, with technical assistance to help promote thoughtful planning and economic growth. The program is partnering with a number of national organizations, including the Natural Resources Defense Council and the Urban Land Institute, to provide the technical assistance.

The Ladders of Opportunity program seeks to help more people reach opportunities by ensuring that the U.S. transportation system provides reliable, safe, and affordable ways to reach jobs, education, and other essential services. LadderS^{TEP} is one part of USDOT's efforts to create those opportunities. Other initiatives in this program include the Safer People, Safer Streets program and resources to encourage local hiring, which ensures that disadvantaged populations have a chance to enter the transportation workforce.

For more information, visit www.transportation.gov/ladders/tep.

Guide Aims to Help Communities Create Safer Streets

FHWA recently published *A Resident's Guide for Creating Safer Communities for Walking and Biking* (FHWA-SA-14-099) to help residents learn about issues that affect walking and biking conditions in their

FHWA's new guide helps residents improve safety for pedestrians and bicyclists in their communities.

communities. The guide is intended to assist residents, parents, community association members, and others with getting involved in making communities safer for pedestrians and bicyclists.

Communities need and want streets that are safe, accessible, and comfortable for all users, whether traveling by car, foot, bike, or mass transit. Streets that are pedestrian- and bicycle-friendly offer many benefits, including reduced collisions, increased travel choices, and improved access and opportunities for all users, including those with disabilities. FHWA designed the guide for use by all individuals looking for ways to improve the safety and comfort of neighborhood streets, whether they are just beginning to learn about traffic safety or are already part of an established safety or advocacy group in the community.

The guide provides examples from other communities working to improve pedestrian and bicycle safety. It includes ideas and resources to help residents learn about issues that affect walking and bicycling conditions, find ways to address or prevent these problems, and promote safety for all road users. Resource sheets at the end of the guide contain checklists, tip sheets, worksheets, and sample materials that can be adapted to meet the needs of any community. The guide also provides an introduction to common safety issues and includes references to other resources and materials for those interested in more indepth information.

For more information, visit http://safety.fhwa.dot.gov/ped_bike/ped_cmnity/ped_walkguide.

FHWA Releases Final Report for EDC-2

As part of its Every Day Counts (EDC) initiative, FHWA partners with State departments of transportation and other stakeholders to speed up innovation in project delivery and roadway safety and sustainability. The second round of the initiative, the 2013–2014 cycle, included 13 innovations selected for deployment to improve the work of highway planning, design, construction, and operation.

Wisconsin DOT

The Wisconsin DOT installed high-friction surface treatments, an EDC-2 innovation, on the ramp from I–94 to I–43 at the Marquette Interchange, shown here, in Milwaukee in 2011. Only 9 crashes occurred in the 3 years following installation, a dramatic decline from the 219 crashes that occurred in the 3 years prior to installation.

FHWA recently released *Every Day Counts: Building a Culture of Innovation for the 21st Century–EDC-2 Final Report*, which presents the results of the 2-year effort to accelerate use of the selected technologies and methodologies. An example is the use of high-friction surface treatments, which are pavement overlay systems that provide exceptional, long-lasting skid resistance at high-crash locations such as horizontal curves and intersection approaches. By the end of the EDC-2 cycle, 37 States; Washington, DC; and Puerto Rico were using high-friction surface treatments, up from just 14 States at the beginning of EDC-2.

For the full report, visit www.fhwa.dot.gov/everydaycounts/reports/edc-2-finalreport.

Colorado Seat Belt Campaign Goes Viral

As part of a May 2015 effort to enforce seat belt use, the Colorado Department of Transportation's Click It or Ticket program ran an unusual billboard campaign. The billboards first appeared with ambiguous, unattributed phrases, such as "Brain Damage," "Life or Death," and "Fatal Accident," printed on a blank background. A week later, CDOT revealed the mystery behind the messages, updating the billboards with images of seat belts crossing out the words "Damage," "Death," and "Fatal." The revised signage, which included notification of the enforcement campaign, a reminder to drivers to buckle up, and CDOT's logo, underscored the message that seat belts can help prevent the negative outcomes associated with vehicle crashes.

CDOT

CDOT

These before (top) and after (bottom) photos show the Colorado billboards displayed during the May 2015 seat belt enforcement campaign.

Even before the reveal, the creative campaign sparked conversations on social media, with the photos reaching more than 220,000 people and receiving 10,000 post interactions. In addition to the 15 billboards in Colorado Springs and Denver, CDOT launched a statewide radio campaign and included messages about seat belt use on gas pumps at 60 gas stations.

In 2014, 156 people who lost their lives in crashes in Colorado were not wearing a seat belt—more than half of the 308 passenger vehicle fatalities that occurred on the State's roadways that year. In 2013, seat belts saved an estimated 12,584 lives nationwide. NHTSA estimates an additional 2,800 lives nationwide could have been saved if all unrestrained passenger vehicle occupants 5 years old and older involved in fatal crashes had been properly restrained.

CDOT

Recipients of Roadway Worker Memorial Scholarship Announced

The American Traffic Safety Services Foundation recently announced the recipients of three Roadway Worker Memorial Scholarships for 2015. The scholarships provide financial assistance for higher education, and applicants must be dependents of workers killed or permanently disabled in work zone crashes. This year, the foundation awarded scholarships to Lyndsay Morgan of Cape Coral, FL; Carl Moser of Middletown, MD; and Andrea Pair of Spiro, OK.

Lyndsay Morgan's father, Steven, was killed in 2011 when he was struck by a motorist in a roadway work zone. Morgan attends Florida Gulf Coast University in Fort Myers, FL, and majors in communications. Carl Moser's father, Richard, was killed after being struck by a pickup truck in 2007. Moser will study electrical and computer engineering at Franklin W. Olin College of Engineering in Needham, MA. Andrea Pair's father, Shannon, was struck and killed by a car in 1998. Pair will pursue a chemistry degree at Northeastern State University in Tahlequa, OK.

The foundation also is seeking help in identifying and encouraging individuals who are eligible to apply for the Roadway Worker Memorial Scholarship. The deadline for 2016 scholarship applications is February 15, 2016.

For more information, visit www.atssa.com or contact Lori Diaz, assistant manager of the foundation, at 540-368-1701 (ext. 150) or lori.diaz@atssa.com.

American Traffic Safety Services Foundation

Student Contest Winners Illustrate Seat Belt Use

At a ceremony in May 2015 at USDOT headquarters in Washington, DC, Secretary Foxx honored two elementary school students who won top honors in the 2015 "Be Ready. Be Buckled." student art contest. Fourth grader Heather Li of Orlando, FL, and second grader Julia Ou of Livingston, NJ, each received framed replicas of their artwork, plus a monetary award.

The annual art contest is organized by the Commercial Motor Vehicle Safety Belt Partnership, which includes the Federal Motor Carrier Safety Administration, NHTSA, and 30 other government agencies and private organizations. It is open to students in kindergarten through sixth grade who also have a sponsor in the commercial truck and bus industries. The contest focuses on urging drivers of trucks, buses, and all other commercial motor vehicles to buckle up to saves lives and reduce injuries.

FMCSA

Second grader Julia Ou won the grand prize in the kindergarten through second grade group for her submission to FMCSA's 2015 "Be Ready. Be Buckled." art contest.

Contest judges select the artwork that best illustrates "the importance of commercial motor vehicle drivers buckling up" with the overarching message of "safety belts save lives." In addition to the grand prize winners in each of two age categories, the submissions of 10 other students will be featured in a 2016 calendar.

Since 2007, overall safety belt use for drivers has steadily increased each year from 65 percent to a current high of 84 percent.

For more information, visit www.fmcsa.dot.gov/safetybelt.

Federal Motor Carrier Safety Administration

FMCSA

Fourth grader Heather Li won the grand prize in the third through sixth grade category for the 2015 "Be Ready. Be Buckled." art contest.

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       Average no. copies each issue during preceding 12 months: 0
       No. copies of single issue published nearest to filing date: 0
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       Average no. copies each issue during preceding 12 months: 3,221
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Lisa A. Shuler, Editor-in-Chief — September 3, 2015

Internet Watch

by Carrie Boris

Connecting with ITS on the Web

Intelligent transportation systems (ITS) are a growing area of interest for the U.S. Department of Transportation, the transportation industry, and the Nation as a whole. Even private companies not normally associated with transportation are conducting research and development on innovations like self-driving cars. By integrating advanced communications technologies into vehicles and infrastructure, ITS can improve transportation safety, mobility, and the environment.

USDOT's Intelligent Transportation Systems Joint Program Office, housed under the Office of the Assistant Secretary for Research and Technology, is responsible for conducting research on ITS across all major transportation modes and coordinating the work of the modal administrations. The ITS Joint Program Office recently released the *ITS Strategic Plan 2015–2019*, outlining the direction and goals of the Federal ITS program and providing a framework for research, development, and adoption activities. The plan has six research areas: connected vehicles, automation, emerging capabilities, enterprise data, interoperability, and accelerating deployment.

To support the increased focus on this area, USDOT has introduced resources for a range of audiences, including a video explaining connected vehicle systems and Web pages with an emphasis on safety-related programs and projects.

An Award-Winning Video

Connected vehicles offer the possibility of improved safety and mobility thanks to integration of technologies like GPS and dedicated short-range communications that enable high-speed, real-time communication between vehicles, roadside infrastructure, and mobile devices. These vehicles can share data anonymously to help prevent crashes and reduce congestion, which can lessen the impact of transportation on the environment by minimizing idling time, reducing fuel use, and lowering emissions.

The ITS Joint Program Office recently produced a 7-minute video using computer-generated animation to help illustrate how connected vehicle technology works. The video shows connected vehicles in action, moving through several scenarios that highlight the technology's benefits in safety, mobility, environment, road weather, and emergency response. The video is available at www.its.dot.gov/library/media/15cv_future.htm.

The video won two prestigious awards: a 2015 Silver Telly Award and a 2015 Communicator Gold Award of Excellence. A highly respected national and international competition, the Telly Awards annually showcase the best work of advertising agencies, production companies, television stations, cable operators, and corporate video departments from around the world. The Communicator Awards honor creative excellence for communications professionals working in print, video, interactive, and audio.

ITS Safety on the Web

The ITS Joint Program Office's Web site at www.its.dot.gov offers a variety of resources to help transportation professionals find the information they need. In addition, the Federal Highway Administration's Office of Safety launched the "Intelligent Transportation System Safety" Web site in fall 2014 at http://safety.fhwa.dot.gov/its.

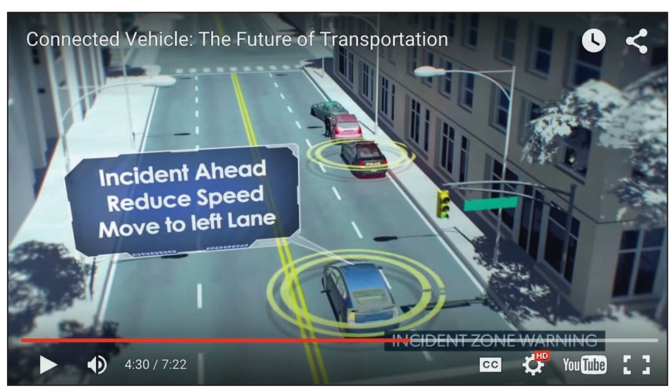
Aimed at State and local agencies, the ITS safety Web pages are a subsection of the Office of Safety's main site. They highlight the role of the office in USDOT's ITS initiatives. "We wanted to let our stakeholders know we are getting more involved in ITS safety," says Karen Timpone, a program manager with the Office of Safety. "The goal is to provide safety-related resources for ITS professionals, especially as connected vehicle technologies begin to be deployed."

As part of the new strategic plan for ITS, the Office of Safety will be working over the next 5 years to promote five safety-related connected vehicle programs: (1) vehicle-to-vehicle communications for safety, (2) vehicle-to-infrastructure communications for safety, (3) vehicle-to-pedestrian technologies, (4) road weather management, and (5) cross-cutting activities, which include architecture, standards, professional capacity building, technology transfer, and evaluation tasks. The ITS safety Web site includes information about each of these programs, as well as links to other resources.

In addition, from the "Useful Links" page, users can access Federal and association resources related to ITS research and programs, including information about standards, national ITS architecture, and professional capacity building.

For more information about ITS safety programs and initiatives, visit http://safety.fhwa.dot.gov/its, or contact Karen Timpone at 202–366–2327 or karen.timpone@dot.gov.

Carrie Boris is a contributing editor for PUBLIC ROADS.



An award-winning video from USDOT uses computer-generated animation to explain connected vehicle technology.

NATIONAL HIGHWAY INSTITUTE

Training Update

by Louisa Ward

Bringing Conference-Style Training to the Desktop

The National Highway Institute serves customers from across the highway sector: State departments of transportation, local public agencies, consultants, and industry professionals. Increasingly, many of them face restrictions on travel, reduced staffing, and limited time, all of which impact their ability to participate in classroom training or conferences, or to host traditional instructor-led training. To help meet the need for training within these constraints, NHI offers a wide variety of Web-based training and webinars.

Now, NHI is working to adopt more advanced technologies and methods to reach remote audiences. The institute has hosted two successful pilot training events in three-dimensional (3–D) virtual worlds: the first in March 2012 and the most recent in March 2015. These events enabled NHI to offer State DOT employees the experience of attending a conference without the time and travel costs. (For more information on the 2015 conference, see "Making Virtual a Reality" on page 14 in this issue of PUBLIC ROADS.)

Meeting Technical Requirements

For the 2015 training event, NHI sought to improve the virtual world experience and take advantage of advances in technology that have occurred since its 2012 pilot. The developers explored options for an avatar- and browser-based, 3–D platform at a lower cost using Voice over Internet Protocol (VoIP) services for communicating within the virtual world. The team wanted a customizable, easy-to-use product that could provide a virtual space that resembled a main conference area, as well as a trade show and breakout rooms.

The platform needed to accommodate a large group of participants. For the 2012 pilot, NHI limited State DOTs to one connection per agency because of concerns about available bandwidth. The new technology needed to offer an improved buffering rate, significantly fewer connection errors, and other enhancements to better handle many users and periods of heavy Internet traffic. These upgrades would enable employees of participating agencies to connect from multiple locations, improving the convenience and flexibility of the virtual conference.

After researching available technologies, NHI selected a platform with features such as participant text chat, avatar customization, video screens, and presentation and collaboration tools. "The VoIP system, which works for most users with little or no configuration, is proximity-based and gives users control over how far they want to project their voices—whisper, normal, or shout," says Silas Nichols, an event organizer. "The system offers administrators important participant management tools like microphone muting and discussion management tools including user polling and laser pointers."

The platform accommodates 100–200 participants per server, and an event may use multiple servers to enable more users to access a single space. However, participants can only interact with others on their own server. For the first use of the new technology at the March 2015 conference, NHI decided to limit the event to 100 participants, including panelists and administrators. This ensured that everyone could network with all users and reduced the likelihood of experiencing bandwidth issues.

Looking Ahead

The platform used for the 2015 conference required the installation of a browser plug-in that enables the 3–D environment and VoIP system to run within the user's Web browser. However, browser plug-ins can cause security concerns. The Chrome™ browser recently dropped support of plug-ins, and other browsers may soon follow.

NHI is working with the Federal Highway Administration's Office of Information Technology Services to analyze alternatives and determine if a virtual world platform exists that will provide greater security while offering the features needed to deliver training virtually. One emerging Web technology enables companies to develop 3–D virtual worlds that run natively in Web browsers without needing a plug-in, which would greatly reduce or eliminate current security concerns.

An overwhelming majority of attendees who completed an evaluation of the March 2015 conference want to see more virtual training events and conferences. NHI is soliciting input on topics and training courses of interest through either a virtual environment or via other means to reach audiences where they are. To share feedback, send an email to NHICustomerService@dot.gov.

For more information, contact Louisa Ward at 703–235–0523 or louisa.ward@dot.gov.

Louisa Ward is a training program manager at NHI.

In this screen capture from NHI's March 2015 geotechnical conference, panelists' avatars sit onstage in the virtual world. A display wall with the results of a participant poll and a presentation slide appear behind them.

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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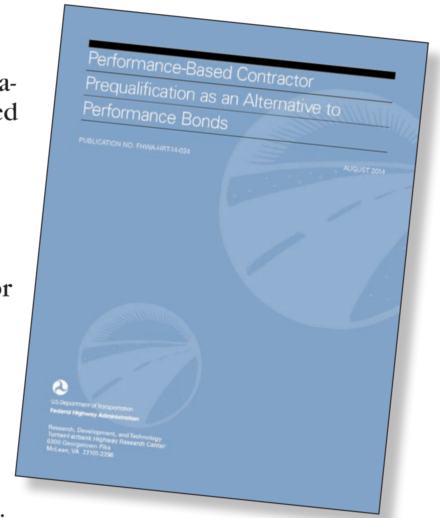
Email: report.center@dot.gov

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).

Performance-Based Contractor Prequalification As an Alternative to Performance Bonds (Report)
Publication Number: FHWA-HRT-14-034

State departments of transportation often rely on construction contractors to build, rehabilitate, and replace infrastructure assets. This report discusses a study that evaluates a performance-based process for prequalification that can help DOTs select qualified contractors.

Researchers examined relevant literature and evaluated the benefits and costs of performance bonds, which are issued by an insurance company to guarantee satisfactory completion of a project by a contractor.



The study examined performance-based contractor prequalification and recommended a more robust three-tiered model.

In the highway industry, one of the main methods to prequalify a contractor is to determine whether a performance bond can be secured. The current performance bonding system does not differentiate between a high-performing and a marginally performing contractor, as long as the two companies have the same level of financial assets. This gives both companies the same opportunity to bid on a project, regardless of performance. In a low-bid environment, the result may be a situation where a State DOT subsidizes marginal performance, which reduces the incentive for top performers to continue superior performance.

After a detailed review of case studies and surveys of contractors, State DOTs, and sureties, researchers found that the rate of default on performance bonds for the industry is less than 1 percent. The research team suggested that the minimum contract value that requires a performance bond be raised to somewhere between $1 million and $10 million from the current minimums set by each State's bonding regulations. Researchers also found that the cost of performance-based prequalification is low compared to the cost of performance bonds.

This document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/14034/index.cfm. Printed copies are available from the PDC.

Use of Radio Frequency Identification Tags in Pavements (Report)
Publication Number: FHWA-HRT-14-061

This report discusses a study evaluating how inexpensive radio frequency identification (RFID) tags can be used in a set of pavement construction applications. Researchers examined the use of RFID tags during construction to identify the spatial location along a roadway for placing truckloads of hot-mix asphalt and portland cement concrete.

In addition to tracking the placement of pavement materials, researchers studied applications for real-time measurement of pavement temperature versus depth and time during intelligent compaction, and early detection of reflection cracking in overlays. They also reviewed guidelines for integration of data on material property, construction, and pavement performance during service using RFID-assisted geolocation.

The first and second phases of the three-phase project addressed the development of techniques for making RFID tags sufficiently rugged to withstand the harsh thermal and mechanical conditions of hot-mix paving and for evaluating survival and read performance of the tags after construction. Researchers identified additional applications of RFID technologies to pavements for assessment. The additional applications include the evaluation of potential problems caused by surfaced tags and the exploration of surface acoustic wave RFID technology for improved performance of small format tags. The third phase of the project focused on evaluating these additional topics.

Researchers found that RFID tracking of hot-mix asphalt placement was the more successful application and the one with the potential for immediate commercial implementation. Tracking of portland cement concrete placement proved to be more of a challenge due to the dielectric properties of concrete. Other applications show promise but need additional research or development. Ongoing followup research funded by FHWA is focusing on expanding the data-gathering capabilities of RFID linked tags.

This report is intended for transportation engineers involved in pavement design, construction, and management, as well as quality acceptance testing of paving materials. The document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/pavements/14061/index.cfm. Printed copies are available from the PDC.

Lightweight Concrete: Shear Performance (Technical Brief)
Publication Number: FHWA-HRT-15-021

Current provisions for lightweight concrete in the American Association of State Highway and Transportation Officials' *LRFD [Load and Resistance Factor Design] Bridge Design Specifications* are based on research from the 1960s. The lightweight concrete that was part of this research used traditional mixes of coarse aggregate, fine aggregate, portland cement, and water. Over the past 50 years, broad-based advancement in concrete technology has enabled significant progress in the mechanical and durability performance of lightweight concrete.

The AASHTO specifications do not cover concrete with a unit weight between that of traditional lightweight concrete and normal-weight concrete. As part of an effort to address this and other perceived shortcomings in how the specifications address lightweight concrete and how lightweight concrete is deployed in bridges, FHWA conducted research to assess the shear performance of these concretes with varying densities. The research team completed 30 full-scale precast, prestressed girder tests and developed a database of shear performance results that covers a wide range of concrete densities. As a result, researchers developed proposed revisions to AASHTO's *LRFD Bridge Design Specifications* as part of a framework that addresses the performance of structural concrete as a function of density. The AASHTO Subcommittee on Bridges and Structures recently debated, refined, and approved these proposed revisions, which will be reflected in future versions of the AASHTO *LRFD Bridge Design Specifications*.

This technical brief describes shear tests on lightweight concrete prestressed girders, summarizes the database of lightweight concrete and normal-weight concrete shear tests, describes a reliability analysis, and presents potential revisions to the *LRFD Bridge Design Specifications* relating to the shear resistance of lightweight concrete.


TECHBRIEF

Lightweight Concrete: Shear Performance

FHWA Publication No.: FHWA-HRT-15-021

FHWA Contact: Ben Graybeal, HRDI-40, (202) 493-3122, benjamin.graybeal@dot.gov

This document is a technical summary of the Federal Highway Administration report *Lightweight Concrete: Shear Performance* (FHWA-HRT-15-022).

Objective

Concrete with a unit weight between that of traditional lightweight concrete and normal-weight concrete (NWC) is not covered in the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) *Bridge Design Specifications*. As part of an effort to address this and other perceived shortcomings in how the specification addresses lightweight concrete and how lightweight concrete is deployed in bridges, research was completed to assess the shear performance of these different density concretes. Thirty full-scale precast, prestressed girder tests were completed, and a database of shear performance results was developed that covered a wide range of concrete densities. Proposed revisions to the AASHTO LRFD *Bridge Design Specifications* were developed and are presented as part of a framework that addresses the performance of structural concrete as a function of density.

Introduction

Much of the fundamental basis for the current lightweight concrete provisions in the AASHTO LRFD *Bridge Design Specifications* is research on lightweight concrete from the 1960s. (See references 1 through 5.) The lightweight concrete that was part of this research used traditional mixes of coarse aggregate, fine aggregate, portland cement, and water. Broad-based advancement in concrete technology over the past 50 years has given rise to significant advancements in concrete mechanical and durability performance. Research during the past

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www.fhwa.dot.gov/research

The document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/15021/index.cfm. Printed copies are available from the PDC.

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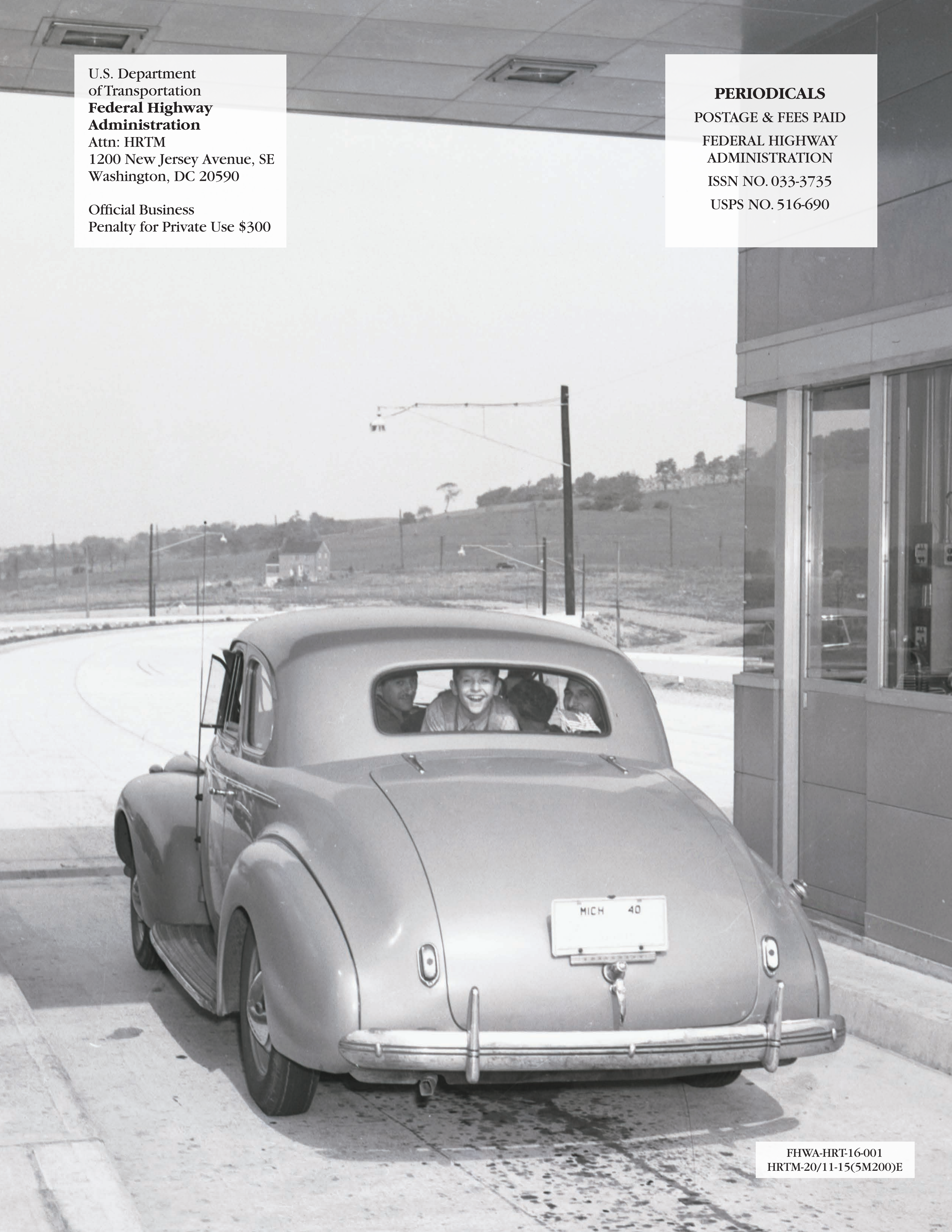

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