Public Roads

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January/February 2017

Every Place Counts
Engaging Local Officials
Quieter Rumble Strips

U.S. Department of Transportation

Federal Highway Administration

Public Roads

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

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Front cover—On December 9, 2015, floodwaters overtopped this county road in Washington's Snoqualmie Valley. The road and bridge were designed to be resilient to significant rain events, so the infrastructure was not damaged. However, extreme weather events and climate change raise questions of vulnerability and resilience that transportation agencies need to consider. For more information, see "Preparing for Change," on page 24 in this issue of PUBLIC ROADS. *Photo: ©Ron Bailey/Getty Images.*

Back cover—Rumble strips have proven effective at reducing roadway departure crashes, but the noise associated with vehicles driving over them is a concern for residents living near highways. Research into rumble strips that produce less noise outside the vehicle, sometimes called "mumble strips," may offer a solution. For more information, see "Did You Hear That?" on page 36 in this issue of PUBLIC ROADS.

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Guest Editorial

Laying the Groundwork for Innovation

The theme for the 2017 annual meeting of the Transportation Research Board (TRB) is Transportation Innovation: Leading the Way in an Era of Rapid Change. This focus presents a timely opportunity to look toward the future of the Nation's transportation system and some of the driving forces for innovation.

In 2015, the U.S. Department of Transportation's *Beyond Traffic 2045: Trends and Choices* kick-started a national conversation on the transportation decisions that need to be made over the next three decades. The report underscores critical decisions facing the country, framed by data-driven analyses, expert opinions, and public engagement.

In an effort to address the challenges raised in *Beyond Traffic* through research and innovation, USDOT has advanced more than $350 million in forward-looking technology deployment partnerships over the past year through the Smart City Challenge, the Advanced Transportation and Congestion Management Technologies Deployment Program, and the Mobility on Demand Sandbox.

Just over a year ago, President Obama signed the Fixing America's Surface Transportation (FAST) Act—the first legislation in more than 10 years that provides long-term funding certainty for surface transportation. The FAST Act offers a springboard for research advancements.

Today's research propels tomorrow's innovation. All facets of transportation—from planning to construction, operations, maintenance, and environmental stewardship—benefit from well-designed and well-funded research and technology programs. The Office of the Assistant Secretary for Research and Technology increases opportunities for cross-modal collaboration on research, while upholding the integrity and impartiality of statistical data.

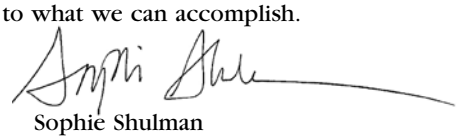
One of the office's key charges in the FAST Act is refreshing the planning and coordination of the agency's research. Through targeted interactions with TRB and its broader stakeholder community, the office has collaborated with USDOT's modal administrations to create the next 5-year *Research, Development, and Technology Strategic Plan* and annual modal research plans. These resources are available on the "Research and Technology" Web site at www.transportation.gov/research-technology.

In December, Secretary Foxx announced $300 million in grants to

32 University Transportation Centers (UTCs). Nine of the grantees selected through the competition are new recipients of UTC Program grants. Thirty partners in the grantee consortia are minority-serving institutions, and seven partners are 2-year institutions. UTCs work with regional, State, and local transportation agencies and private sector partners to help find solutions to challenges that directly impact their communities and affect the efficiency of the Nation's transportation system, as well as to educate the next generation of transportation leaders.

Transportation connects people—and connections provide economic opportunity and social mobility. The emergence of driverless cars, unmanned package deliveries, smart cities, and other exciting changes demonstrates how innovative technology is playing a key role in ensuring the system's safety and reliability, while offering more Americans the ability to access economic opportunity. The new National Transit Map, recently published by the Bureau of Transportation Statistics, offers a nationwide catalog of fixed-guideway and fixed-route transit service, further facilitating the conversation about access to opportunity.

Collectively, the people of this great Nation have proven to be our finest assets. When innovative and creative research hits the road, there is no limit to what we can accomplish.



Sophie Shulman
Acting Assistant Secretary for
Research and Technology
U.S. Department of Transportation

INNOVATION CORNER

by Tony Furst

Q&A: The New Office of Innovative Program Delivery

In 2016, the Federal Highway Administration began retooling the Office of Innovative Program Delivery (OIPD) to expand the agency's ability to advance innovation in the transportation community. This expansion involved the restructuring of four individual centers focusing on innovative finance, acceleration of innovation, local-aid support, and transportation workforce development. Following this overview of the new OIPD and its four centers, future issues of this column in PUBLIC ROADS will focus in turn on each of the individual centers.

What's new about the Office of Innovative Program Delivery? FHWA is committed to facilitating a thriving culture of innovation across the transportation community by expanding the integration of new technologies and practices. The change in OIPD demonstrates that commitment. Originally focused on innovative finance, OIPD now advances innovation across a broader range of crosscutting functions. Combining these functions in one office improves the focus and increases the visibility of FHWA's efforts to provide leadership on innovation and thus influence change.

> *"FHWA is committed to facilitating a thriving culture of innovation across the transportation community."*

How has the focus on innovative finance changed? The Center for Innovative Finance Support retains OIPD's original mission, with its focus on the Federal-Aid Highway Program. Using tools such as Grant Anticipation Revenue Vehicles (GARVEEs), State Infrastructure Banks, and tolling and public-private partnerships, this center provides the expertise to deliver complex and costly infrastructure projects. The center also acts as FHWA's liaison with the U.S. Department of Transportation's new Build America Bureau, which streamlines the use of Federal credit assistance across USDOT and coordinates technical assistance for projects receiving bureau support.

Has the Center for Accelerating Innovation changed? The Center for Accelerating Innovation will continue to lead its highly successful partnership with the States to deploy innovative technologies and practices rapidly into transportation operations through the Every Day Counts initiative. This center will remain FHWA's focal point for advancing new technologies and practices. It will work across FHWA, through its advanced market readiness program and with the recently completed nationwide network of State Transportation Innovation Councils. In short, the Center for Accelerating Innovation will identify, develop, and implement innovations to improve the transportation system.

Visit the OIPD Web site to learn about the innovative programs and services offered by the four centers and how to access them.

How does the Center for Local-Aid Support fit into the picture? Agencies at all levels of government are striving to meet customer demands for a safe, reliable transportation system in an era of constrained budgets. The Center for Local-Aid Support works with the local, tribal, and Federal land management agencies to understand their needs and then provide training and assistance on innovative technologies and practices through the national network of Local and Tribal Technical Assistance Program centers and the Coordinated Technology Implementation Program (CTIP, the Federal lands component).

What does the Center for Transportation Workforce Development do? This center will invigorate new and established stakeholder relationships to collaboratively encourage and promote a workforce that can meet the Nation's transportation needs. From elementary school to advanced schooling, this center will propose, explore, and act on approaches to meet the education and training needs of professionals and practitioners in the highway construction and operation industries. Working with the transportation community, the center will identify needed skills and develop innovative solutions to close gaps and ensure a qualified workforce.

By bringing together four centers that advance innovation, FHWA has created a convenient, central source for State transportation departments and local and tribal agencies seeking information and assistance on implementing the latest highway construction technologies and processes. To learn more, visit www.fhwa.dot.gov/innovativeprograms.

OFFICE OF INNOVATIVE PROGRAM DELIVERY

Tony Furst is FHWA's chief innovation officer and head of the Office of Innovative Program Delivery.

by Robert Ritter

Financing the Future

Public funds used by State and local governments to build, operate, and maintain the national transportation network are under pressure. The current backlog of needed but unfunded investments in transportation infrastructure in the United States will be almost $1 trillion by 2025. The passage of the Fixing America's Surface Transportation (FAST) Act stabilizes longer term investment, but the funds it provides are insufficient.

Thankfully, an array of effective financing tools can provide agencies with options to help fill the deficit. Over the past two decades, through the authority provided by Congress, the Federal Highway Administration has introduced innovative financing techniques that can expand the capacity of the Federal-Aid Highway Program. These options may be complex and time-consuming to those encountering them for the first time, but FHWA and the U.S. Department of Transportation can help.

Centralized Assistance for Financing

The Center for Innovative Finance Support, one of four centers under FHWA's new Office of Innovative Program Delivery, specializes in helping project sponsors identify the most appropriate methods for financing their highway projects, and then provides technical assistance to navigate the process.

Substantially completed in December 2016, the Ohio River Bridges Downtown Crossing in Louisville, KY, shown here, was financed using GARVEE bonds, toll revenue bonds, and a USDOT TIFIA loan. *Photo: Ohio River Bridges Downtown Crossing.*

"Maintaining a level of corporate knowledge of these tools can be difficult," says Mark Sullivan, director of the center. "We hope to provide a consistent repository of research, training, and expertise that States can tap to finance projects."

The center provides assistance with many highway financing options, including Grant Anticipation Revenue Vehicles (GARVEEs), State infrastructure banks, tolling, and pricing, among others. "We don't promote a specific approach," explains Sullivan. "We work together with stakeholders to craft the approach that best fits their needs, and then walk them through all the way."

"Just raise your hand and ask for help," he says. "We can start wherever you are."

Building Greater Support

Most requests to the center are referrals from either FHWA division offices, which work directly with State departments of transportation to deliver more than $40 billion annually nationwide, or USDOT's new Build America Bureau. Created as a "one-stop shop" for project sponsors seeking credit opportunities or technical assistance with public-private partnerships, transit-oriented development, or environmental permitting, the bureau is responsible for driving large transportation infrastructure projects in the United States.

> *"If your project is large, multimodal, and may involve multiple financing tools, call the Build America Bureau."*
>
> *—Jodie Misiak, Project Development Director*

Mandated under the FAST Act, the bureau combines multiple loan, bond, grant, and public-private partnership programs under one roof. It focuses on large, complex, multimodal projects that may involve multiple jurisdictions and funding streams, a description that fits many of the most innovative highway projects. The bureau's financing and funding tools include loans under the Transportation Infrastructure Finance and Innovation Act (TIFIA) and the Railroad Rehabilitation and Improvement Financing program, private activity bonds, and the Fostering Advancements in Shipping and Transportation for the Long-term Achievement of National Efficiencies (FASTLANE) grant program.

"Build America has a broad scope," says Jodie Misiak, project development director for the bureau. "We handle projects that cut across modes and may combine multiple financing approaches. When we need highway expertise, we call FHWA's Center for Innovative Finance Support."

The goal is to connect project sponsors with the people who can assist them as quickly as possible. "We want them to get the most efficient help," Misiak says. "That way projects aren't sitting there waiting for answers. If your project is large, multimodal, and may involve multiple financing tools, call the bureau. If it is highway specific, call your division office. But either way, the Center for Innovative Finance Support might be asked to provide its expertise."

"There are a lot of good projects out there," says Sullivan. "Our job is to ensure they find the financing they need to make it off the drawing board."

For more information about the Center for Innovative Finance Support, visit www.fhwa.dot.gov/ipd. To learn more about the Build America Bureau, visit www.transportation.gov/buildamerica.

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

Peering Into the Crystal Ball

Looking back at the past and understanding the trends that are emerging today can provide clues to the future of transportation.

by Heather Marie Rose

Last year marked the centennial of the Federal Aid Road Act of 1916 and the 50th anniversary of the U.S. Department of Transportation. Looking back over those 100 years, the transportation system of today bears little resemblance to that of 1916. Looking forward, a reasonable assumption is that past transformations suggest the magnitude of change that is likely to occur over the next 50 years.

Roadways, pathways, rails, and air travel will perhaps be worlds apart from today's transportation system and differ in ways that are difficult to imagine. In many respects, however, the seeds of coming changes are visible in the trends that are emerging now. Identifying and interpreting those emerging trends can help transportation policymakers and decisionmakers plan for the future. For example, the Federal Highway Administration's Office of Transportation Policy Studies uses data, expertise, and models to look back at the past, understand the here and now, and forecast which trends are shaping transportation's future and in what ways.

"Helping transportation decisionmakers determine how emerging trends will factor into future transportation needs is central to FHWA's mission," explains Mary Beth Zimmerman, director of the FHWA Office of Transportation Policy Studies.

With the pace of change in technology today, the identification of emerging trends can be challenging—especially pinpointing those that influence some aspect of transportation and are likely to have lasting impacts. Sometimes the implications of change are obvious. Other times, changes are more subtle or seemingly unrelated. Identifying the trends that matter is the first step.

Analyzing data is central to identifying and interpreting trends. Data series, which permit the examination of data over time, are even more critical to identifying emerging trends. Looking at both the influencers (inputs) and the travel indicators (outputs) helps to identify trends and the size and direction of those trends. For example, demographics and climate change are among the inputs, while vehicle ownership and miles driven are among the outputs.

"Understanding and interpreting emerging trends is necessary to assess the magnitude and direction of the change, as well as its permanency, cause, and potential impacts on transportation," says Associate Administrator David Howard of the FHWA Office of Policy and Governmental Affairs. "Often this involves complex analysis and modeling. Other times it is as simple as looking at the data in the context of what is already known."

Looking Back

Travel occurs for many reasons. People travel to and from work, to doctors, on vacation, and to school. Goods ship to and from warehouses, ports, farms, factories, and retail stores. Against this backdrop of the movement of people and goods across the United States, change is also taking place in the population, economy, land use, and technology.

(Above) The shared use of bicycles like these being accessed at an urban station is an innovative emerging trend in transportation. *Photo: © maximkabb, Getty Images.*

Important travel measures, such as trip rates, mode share, travel party size, and average trip distance, do not change significantly from year to year, for the most part. During some periods, however, changes of a greater magnitude have created significant alterations in how, when, and why people travel. Sometimes these transformations have been spurred by system improvements, but other times change is driven by economic and social factors.

The construction of the Nation's highway system offers an example of a major shift in travel demand caused by system improvements. Major changes occurred as surface transportation in the United States expanded from dirt roads with few route options to a modern system of connected streets, highways, and, in the 1950s and 1960s, interstates.

For an example of the impact of social changes, consider the rise in vehicle miles traveled (VMT) during the 1970s and 1980s as the employment rate among women soared to unprecedented levels. More recently, social, demographic, and technological factors are creating rapid changes in certain aspects of transportation, including its funding, modal options, and system management.

The rise in VMT is an example of a trend influenced by economic factors. Since World War II, vehicle travel has been growing steadily and consistently, except for brief interruptions due to major wars, recessions, or oil crises. A significant decline occurred in November 2007 because of the Great Recession. The permanency of this trend was at first unclear, and many experts forecast a new, lasting downward trend in vehicle travel. Because VMT is strongly related to personal income, how much of the decline was due to recessionary influences is unclear, versus how much represented a real shift in car dependency. The answer has perhaps revealed itself in the data from 2016. VMT rebounded that year, surpassing its 2007 peak, and is currently growing toward new record highs.

One trend that could have significant implications for policy, planning, and funding allocations is the increasing urbanization of the U.S. population. The rise in urban living is an example of a trend that is largely misinterpreted. Using the census definition of a metropolitan statistical area (MSA), the population of the United States is becoming more urbanized. However, the growth of the MSA population does not necessarily equate to growth in urban population. The MSA census areas include urban cores, but they also contain suburban counties and small towns.

Overall, the United States is still trending toward suburbanization, with nearly half of the population living in suburban neighborhoods. But the suburbs often lack robust transportation alternatives such as transit, carpool programs, and bicycle lanes. As a consequence, suburban households are more dependent on automobiles. A study by Matthew Kahn in 2000, published as *The Environmental Impact of Suburbanization*, found that suburban households drove 31 percent more than their urban counterparts.

Census data indicate that the growth in suburban populations includes a sizable increase in low-income populations in the suburbs. Because of the growing number of the poor in suburban and small metropolitan areas, the future may bring an increased demand for alternative travel modes outside the central cities. Hence, because migration to postwar suburbs has had such a profound effect on increasing automotive use and dependence, understanding the expected trends in future urbanization and suburbanization is crucial.

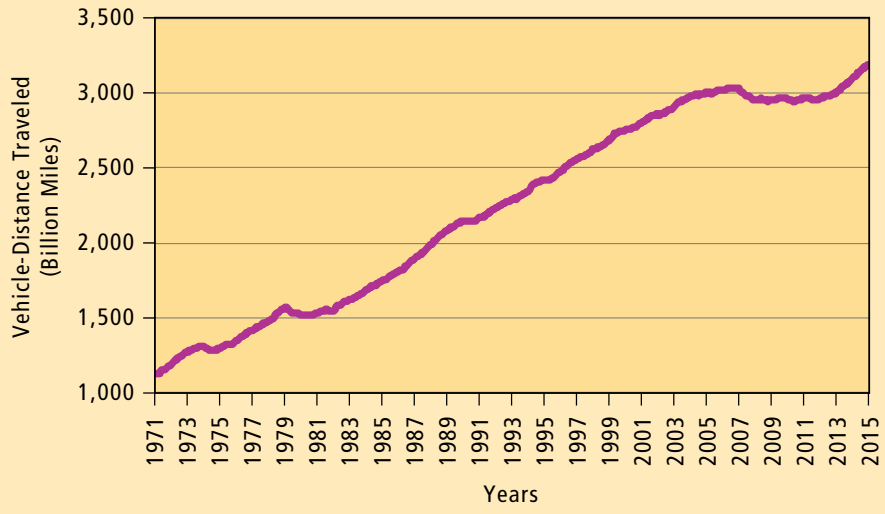
Thinking About The Here and Now

To understand current and emerging trends and what they might mean for the future of transportation, FHWA engages stakeholders from industry, government, and academia through workshops, meetings, and visioning sessions. These discussions bring new perspectives, ideas, and hypotheses to the forefront and enable FHWA to conduct research that is informed and relevant.

A recent visioning session on the future of rural transportation revealed new perspectives related to the impacts of global climate change on transportation. The impact of climate change is often considered with respect to increases in severe weather events and coastal flooding. But in rural agricultural communities, climate change is affecting the locations of agricultural production.

For example, some farmers in North Dakota are shifting from growing wheat to corn in response to the changing climate. North Dakota has long been a leading supplier of durum wheat, which is used to make pastas and for which the demand remains strong. Similarly, although

Vehicle-Miles Traveled on All U.S. Roads: 1971 to 2015



VMT rebounded in 2015, surpassing its 2007 peak, and is currently growing toward new record highs. *Source: FHWA Office of Highway Policy Information.*

Nearly half of the U.S. population lives in suburban neighborhoods. Metropolitan areas are growing, increasing the need for transportation between cities and their suburbs. Shown here is the Oakland Bay Bridge, which links San Francisco and Oakland, CA. *Photo: Department of Defense in National Archives.*

ethanol production has driven expansion of the corn market, changes in the growing season driven by climate change are also becoming a factor in corn production. Shifting markets create shifts in transportation demand for moving agricultural products to market. The U.S. agricultural market makes up 22 percent of all transport tonnage. Shifting production and changing commodities require new and changing transportation infrastructure to move agricultural goods nationally and globally.

In addition, long-term projections suggest that crop production in current Midwestern locations is likely to decline as a result of climate change, which may lead farmers to move production northward to offset those impacts. These types of emerging trends have broad implications for the future needs for freight transportation, as regional commodities change and supply chains shift over time.

Another emerging trend in the forefront of national discussions on transportation policy is the sharing economy, which involves renting and borrowing goods and services, rather than owning them. Shared mobility—the shared use of a vehicle, bicycle, or other mode—is an innovative transportation strategy that enables users to have short-term access to transportation on an as-needed basis. Advances in social networking, mobile technologies, and centralized pickup locations enable users to access a car, bike, or even a Segway on demand.

The use and availability of shared modes of travel is growing rapidly. Car sharing, or short-term auto use, is a major segment of the shared mobility industry. As of July 2015, there were 22 car-sharing operators in the United States, with more than 1.1 million members and over 19,000 shared vehicles. Shared mobility systems provide a number of benefits to users, including lower user cost, more transportation options, and increased mobility. This new model of transportation access may have transformative implications for future travelers: for example, increased access to essential economic centers for disadvantaged populations such as the poor, elderly, or disabled. In addition, shared mobility may provide low-cost mobility and access solutions for areas such as suburban and rural communities lacking robust transit alternatives.

Climate change is driving farmers to shift production to different crops, such as the corn shown here, having implications for future freight transportation needs. *Photo: North Dakota State University.*

Looking Forward

Analyzing past trends and engaging in policy discussions on today's transportation system create the foundation for research on emerging trends, helping to identify and explain what is occurring and why. When looking forward, the FHWA Office of Transportation Policy Studies examines how emerging trends may affect the transportation system of the future. Two important tools in envisioning transportation futures are scenario planning and modeling.

Traditionally, the transportation community has used the scenario planning technique as a tool to help minimize ambiguity in visualizing the future. Policy research on connected and automated vehicles offers an example of the use of scenario planning. These technologies are moving rapidly toward deployment and commercialization, and both have the potential to cause profound changes to transportation systems.

Currently, FHWA is preparing to conduct a scenario planning study on the deployment of connected and automated vehicles. The FHWA study will produce future scenario

outcomes, a high-level assessment of those potential outcomes, and an illustration of how agencies can use this form of planning to develop their own, more localized scenarios visualizing the future of connected and automated vehicles. The study, Transportation Scenario Planning for Connected and Automated Vehicles, also will provide appropriate frameworks for decisionmaking, so that transportation practitioners can take sensible immediate actions in anticipation of transformational changes that are likely to occur over long time horizons. The study is scheduled to start in January 2017, with results available in mid-2018. For more information, contact Max Azizi (max.azizi@dot.gov).

To model the impacts of future trends, the Office of Transportation Policy Studies works with various forecasting models. For example, the office uses FHWA's Highway Economic Requirements System (HERS) to project the overall conditions and performance of the Nation's highways at alternative potential levels of investment over a 20-year period.

Among the performance measures used is the average cost per mile traveled in vehicle operating expense, travel time, and crashes. Projecting these costs entails detailed modeling and assumptions that are often influenced by emerging trends.

For example, the assumptions on future growth in vehicle fuel efficiency are based on projections by the U.S. Energy Information Administration (*Annual Energy Outlook* series) that incorporate expected impacts of fuel economy regulations, oil prices, and technological trends.

The Highway Economic Requirements System also incorporates projections for growth in traffic volumes by vehicle type (light versus heavy duty) based on a forecasting model developed for FHWA by the Volpe National Transportation Systems Center. These projections are necessarily speculative because future economic trends and the extent to which short-term changes represent long-term trends are uncertain. The assumptions about VMT growth strongly influence the HERS estimates of the funding levels needed to achieve specific national targets for highway conditions and performance. FHWA regularly examines the sensitivity of these estimates to changes in these and other assumptions.

New mobile technologies and mapping capabilities, as shown on this smartphone, are providing more and improved information on transportation and have spurred emerging shared modes of travel. *Photo: Adam Cohen, Berkeley.*

What's the Takeaway Message?

Over the last century, the characteristics of the movement of goods and people in the United States have changed dramatically. Internal and external factors, such as changing population, economics, technology, and climate all influence demand on the transportation system. Policy research is essential for informing decisionmakers on key opportunities and challenges so that the transportation system can continue to evolve with the needs of the times and, as a result, remain one of the best systems in the world. The transportation system has facilitated economic growth and prosperity, the expansion of towns and cities, and increased mobility for the traveling public.

"If the past is any indication of the future, the transportation system will continue to evolve as people, industry, and needs change," says FHWA Associate Administrator Michael F. Trentacoste, Office of Research, Development, and Technology. "Identifying and understanding emerging trends provides the opportunity to anticipate and plan for future transportation needs—and will continue to be an important function for FHWA."

Heather Marie Rose manages the Transportation Futures Team for the FHWA Office of Transportation Policy Studies, where she leads transportation policy research and analysis in the context of emerging social, demographic, technological, and economic trends. She holds a master's degree in political science from the University of Florida and a bachelor's in political science from the University of Central Florida.

For more information, see www.fhwa.dot.gov/policy/otps or contact Erica Interrante at 202-366-5048 or erica.interrante@dot.gov.

Projected Growth in Vehicle Miles Traveled

Vehicle Class	Compound Annual Growth Rates	
	2014–2034 (20 Years)	2014–2044 (30 Years)
Light-Duty Vehicles	0.81%	0.47%
Single-Unit Trucks	1.73%	1.50%
Combination Trucks	2.08%	1.87%
Total	**0.92%**	**0.61%**

Source: FHWA, Spring 2016.

by Kay Fitzpatrick, Ann Do, Michael P. Pratt, and Bruce Friedman

Encouraging Best Behavior

The results are in from recent FHWA research: Pedestrian hybrid beacons continue to improve safety at unsignalized crossings.

(Above) Shown here is a pedestrian hybrid beacon in Tucson, AZ. *Photo: Martha Lochert Photography.*

Since their development in the late 1990s, pedestrian hybrid beacons (PHBs) are seeing increased use. This street crossing treatment, which consists of pedestrian signal faces for those pedestrians entering a marked crosswalk and beacon faces for drivers of vehicles who are about to pass through the crosswalk, is successful in reducing the number of pedestrian-vehicle conflicts.

Compared to conventional midblock pedestrian signals, PHBs allow greater vehicular throughput on major streets, especially at sites with long crosswalks, because drivers have the option of proceeding after stopping during the pedestrian's flashing Don't Walk interval if they can do so without conflicting with pedestrians. Furthermore, as noted in a 2010 study released by the Federal Highway Administration, *Safety Effectiveness of the HAWK Pedestrian Crossing Treatment* (FHWA-HRT-10-042), the "PHB can provide greater safety than the other pedestrian crossing options for crossing busy arterials without the drawbacks of a traditional signal. Whereas [previous research shows] traditional signals may increase crashes, especially rear-end crashes, the PHB has been found to reduce the potential for pedestrian crashes by 69 percent and total crashes by 29 percent for great overall safety."

Despite such success, some transportation engineers remain reluctant to implement PHBs and continue to ask questions about the performance of the treatment. For example, when the PHB rests in a dark (unlighted) indication, do some drivers mistake it for a malfunctioning signal and stop needlessly? How do drivers on minor approaches (cross streets

or driveways near the crossing) behave when the PHB sequence is active? How well do drivers and pedestrians comply with the control that the PHB provides for them, and do pedestrians consistently push the button before crossing?

In 2016, FHWA published the results of a followup research project, *Evaluation of Pedestrian Hybrid Beacon and Rapid Flashing Beacons* (FHWA-HRT-16-040) to answer such questions by recording driver and pedestrian behaviors at existing sites.

Monique Evans, director of the Office of Safety Research and Development with FHWA, says, "As long as pedestrians are involved in fatality and injury crashes, identifying and promoting treatments that improve pedestrian safety and mobility will be an important part of what we do.... We want to encourage agencies to adopt practices and use tools that make it easier and safer for pedestrians to travel from place to place."

Answering engineers' questions by providing evidence of the efficacy of PHBs could go a long way toward promoting their use.

What Are PHBs?

PHBs are thought to offer increased safety in uncontrolled, marked crosswalks by raising motorist awareness of the presence of pedestrians at those locations and by displaying red signal indications (either steady or flashing) that legally require drivers to stop.

PHBs differ from traditional midblock pedestrian signals and constantly flashing warnings in that the PHB indications remain in an unlighted state for drivers until activated by a passive pedestrian detector or a pedestrian button press. When activated, the PHB sequence for drivers begins with a flashing yellow indication followed by a steady yellow indication to alert them to the upcoming need to stop for pedestrians. Then the PHB presents a dual steady red indication for drivers and a Walk indication for pedestrians, followed by alternating flashing red indications for drivers while pedestrians see their flashing Don't Walk indication and on most installations a countdown indication. This sequence requires drivers to stop and remain stopped while pedestrians cross, but allows drivers to proceed with caution after stopping if they can do so without conflicting with pedestrians.

Communities can use the PHB at several types of locations, including midblock marked locations where pedestrians need assistance across a major street, or crossings near minor approaches such as cross streets or driveways. On major streets that have medians wide enough to serve as a pedestrian refuge area, communities have used PHBs to enable two-staged crossings where each side of the road is controlled independently.

The Early Years

Richard B. Nassi, P.E., Ph.D., a retired transportation administrator for Tucson, AZ, developed the first PHB, then known as a High-intensity Activated crossWalK (or HAWK), after returning from a trip to England where a similar beacon was in use. Nassi noted, "The PHB (HAWK) was chosen over the traditional [traffic control] signal because a signal at a crossing at a residential street frequently will attract unwanted traffic and speeds to the residential street, turning it into a de facto [minor] arterial street and creating neighborhood traffic mitigation problems." The increase in traffic and speeds occurs because a signal can create a gap in the major traffic stream, encouraging more "cut through" traffic on the residential street. This traffic can be associated with higher speeds.

In the late 1990s, the city of Tucson started using PHBs, and since then at least 42 States plus the District of Columbia and the Indian nations in Arizona have joined in.

In 2009, the PHB was added to part 4 of the *Manual on Uniform Traffic Control Devices* (MUTCD). The MUTCD allows the PHB to be installed at a marked crosswalk where a traffic signal is not warranted, or a signal could be warranted but a decision has been made not to install it. Warrants in the MUTCD chapter 4F assist in determining whether a PHB would be potentially beneficial based on vehicle and pedestrian volumes, vehicle speeds, and crosswalk length (see paragraphs 5 through 8 of section 4F.01). Additional guidelines address questions about signing, pavement marking, and timing the durations of the vehicular and pedestrian indications.

Since 2010, the city of Austin, TX, has installed 45 PHBs. Gary Schatz, former city transportation engineer, reports that "the decision to install PHBs was based on the fact that the community was frustrated with the apparent lack of effectiveness of flashing warning beacons and marked crosswalks alone. By implementing PHBs, the city of Austin was better able to meet community expectations [for a majority of motorists to stop in advance of the crosswalks]. We received numerous letters of thanks and appreciation for installing PHBs."

Similarly, Nassi reports that the city of Tucson has more than 100 installations and, to date, has not had a fatal crash at any of the PHB crossings.

In spite of these positive results, engineers' remaining questions led FHWA to conduct an open-road study with the objective of examining actual driver and pedestrian behaviors at crosswalks with PHBs.

The lower indication on this PHB shows steady yellow, which comes after it shows flashing yellow, alerting drivers to the upcoming need to stop for pedestrians. *Photo: Martha Lochert Photography.*

Selection of Study Sites

The FHWA research team for the *Evaluation of Pedestrian Hybrid Beacons and Rapid Flashing Beacons* study, which covers October 2012–March 2016, identified a total of 20 study sites in Austin, TX, and Tucson, AZ, two cities that have used the PHB extensively. The study sites collectively represented a range of key characteristics, such as traffic volume, speed limit, number of lanes, and median width and type.

Some sites are located at stop-controlled intersections, others near driveways, and others at midblock locations where pedestrians cross. The sites are in a variety of areas, including suburban residential neighborhoods, school campuses, and in sites near small and large businesses.

Data Collection And Reduction

From the selected sites, the research team collected nearly 80 hours of video footage, observing approximately 1,100 PHB activations and nearly 2,000 pedestrian crossings at PHB-controlled crosswalks. Approximately 1,700 of the observed pedestrians were members of the public (nonstaged pedestrians), and about 300 were members of the research team conducting staged crossings. The researchers then reduced the data by reviewing the video footage to obtain insights into driver and pedestrian behaviors, as well as the prevalence of pedestrian-vehicle conflicts.

Driver Behavior

Overall, about 96 percent of drivers yielded to pedestrians in the crosswalk when the PHB was active at the studied sites. A small number of violations occurred where drivers either ran the steady or flashing red indications or proceeded during flashing red when pedestrians were still present in the crosswalk. Most of these violations occurred either a short time after the start of the steady red indication or immediately after pedestrians had cleared the driver's lane.

Researchers observed no drivers stopping solely because the dark PHB was present. They did observe a small number of stops in the presence of a dark PHB because of congestion on the street or because a pedestrian was using the crosswalk without first activating the PHBs but none while traffic was flowing freely and the crosswalk was clear.

Researchers closely observed the behavior of minor-movement drivers—those traveling on or turning onto the minor crossroad at an intersection—while PHBs were active. This effort included drivers who did not have to pass through the beacon-controlled crosswalk but were still required to stop because of STOP signs (drivers on cross streets or driveways) or the PHBs' red indications (drivers making a left turn from the major street). The analysis revealed that minor-movement drivers would often use gaps that were created in the major-street traffic while the PHB was active, taking advantage of the opportunity to complete their maneuver.

Stop compliance was generally high among minor-movement drivers, although violation rates were notably high (five violations per hour or more) for movements at seven of the sites. These movements were for drivers entering or exiting major traffic generators such as school campuses or well-patronized supermarkets. The observed violations did not involve any interaction with pedestrians in the PHB-controlled crosswalks.

Pedestrian Behavior

The 1,700 nonstaged pedestrians were generally compliant with the PHB indications. About 80 percent began their crossing movements while the steady or flashing red indications were provided to drivers. Only about 7 percent of the nonstaged pedestrians started crossing while the PHB was dark, and these crossings typically occurred during periods

These two PHB indications show steady red, so drivers must stop and remain stopped. *Photo: Martha Lochert Photography.*

of low vehicular volume when it was easy for pedestrians to cross.

Pedestrian compliance was higher at sites that had higher vehicular volumes. Specifically, only 20 percent of all observed noncompliant crossings occurred when vehicular volumes exceeded 6 vehicles per minute per lane, and less than 5 percent occurred when vehicular volumes exceeded 10 vehicles per minute per lane.

The research team observed the nonstaged pedestrians to determine how often they pushed the button before crossing at the beacon-controlled crosswalk. This analysis revealed that more than 90 percent of pedestrians who could have pushed the button (because they intended to cross and other pedestrians had not yet pushed the button) did so. Pushbutton usage was especially common at sites with vehicle volumes in excess of 2,000 vehicles per hour. At these sites, less than 5 percent of pedestrians chose not to push the button if they arrived while the PHB was inactive. In addition, more than 80 percent of pedestrians who pushed the button waited for their Walk indication before beginning to cross.

Of the 20 PHB data collection sites, 18 operated in "hot-button" mode where the PHB became active immediately when a pedestrian pushed a button. The other two sites were coordinated with adjacent traffic signals such that they would provide pedestrian service when platooned vehicles were not present on the major street.

Pedestrian behavior differed at the two coordinated sites in that a larger percentage of pedestrians started crossing while the PHB was inactive. At hot-button sites, about 6 percent of pedestrians started crossing during the dark indication, while about 13 percent of pedestrians did so at the coordinated sites. Departures on the dark indication were less common at the coordinated site that had pushbuttons next to red pilot lights that would illuminate when the button was pressed.

Pedestrian-Vehicle Conflicts

The research team reviewed the video footage to determine the rate of pedestrian-vehicle conflicts. A conflict was considered to occur when the driver or the pedestrian could be seen making a sudden change in their path or speed, suggesting that they perceived the potential for a crash. The researchers observed a total of 54 conflicts in the video footage, 38 involving through vehicles and 16 involving turning vehicles.

One key predictor of conflict rate is pedestrian compliance; pedestrians who started crossing against a steady or flashing Don't Walk indication were about 58 percent more likely to experience a conflict with a vehicle. A notable number of these conflicts occurred at one of the sites that was operated in coordinated mode. The pedestrian pushbuttons at this site lacked audible or visual indicators that the button press had been registered, so it is likely that some pedestrians believed that the PHB was malfunctioning and decided not to wait for the start of the PHB sequence.

Many of the conflicts that involved turning vehicles occurred at a particular site that had high volumes of both pedestrians and vehicles, where the crosswalk was near a bus stop, or about 45 feet (14 meters) from a driveway serving a well-patronized supermarket. Drivers making left turns out of the driveway had little space to complete their turning movement before encountering the occupied crosswalk, and would sometimes encroach on pedestrians while trying to maneuver out of their diagonally oriented position. No conflicts were observed at a similar site that also had busy bus stops and a well-patronized supermarket, but with the distinction that the crosswalk was about 60 feet (18 meters) away from the driveway.

The Results

This study of operations and behavior of both drivers and pedestrians differs from previous FHWA studies of the PHB, which focused on safety (*Safety Effectiveness of the HAWK Pedestrian Crossing Treatment*). In the nearly 80 hours of video footage, very few drivers stopped when they

After the red indications start alternately flashing red, as shown in this pair of photos, drivers may proceed after a complete stop if they can do so without conflicting with pedestrians. *Photos: Martha Lochert Photography.*

This pedestrian is crossing at a PHB on a wide arterial road. *Photo: Martha Lochert Photography.*

encountered a PHB in a dark, inactive mode, and these drivers stopped either because of congestion on the street or because a pedestrian was crossing while the device was inactive. No drivers stopped because they mistook a dark PHB to be a malfunctioning traffic signal.

Driver yielding rates were high (about 96 percent) across the 20 PHB-controlled sites. Pedestrian compliance was also high, as about 70 percent of the observed pedestrians started crossing during the drivers' steady red indication (when the pedestrians had a Walk indication), and more than 90 percent of pedestrians pushed the button when they intended to cross and the PHB was inactive. High compliance on the part of both drivers and pedestrians show that the PHB has significant potential to improve pedestrian safety at unsignalized crossing locations.

The MUTCD recommends that PHBs be coordinated with adjacent traffic signals if installed within a signal system, and 2 of the 20 PHB sites in this study were coordinated. Pedestrian departures on the dark indication were more common at the coordinated sites, although compliance was better at the coordinated site that had pushbuttons with red pilot lights to indicate PHB activation, compared with the coordinated site that did not have visual or audible confirmation of the button press.

Pedestrian-vehicle conflicts occurred more frequently with through vehicles than turning vehicles, particularly when the pedestrian was noncompliant. Some conflicts that involved turning vehicles occurred when drivers were making left turns out of a driveway that served a major traffic generator and the distance between the driveway and the crosswalk was not sufficient to allow the driver to complete the left-turning movement before encountering the crosswalk.

By incorporating the PHB in the 2009 MUTCD, FHWA made this pedestrian safety device available to practitioners to use at uncontrolled marked crosswalks to enhance pedestrian safety. FHWA plans to encourage more frequent implementation of PHBs at locations where they can be beneficial by proposing the elimination of the current recommendation that PHBs be located at least 100 feet (30 meters) from side streets or driveways that are controlled by STOP or YIELD signs. FHWA is also encouraging use of PHBs as one of the pedestrian safety countermeasures in an innovation called Safe Transportation for Every Pedestrian (STEP) being promoted under the fourth round of Every Day Counts (www.fhwa.dot.gov/innovation/everydaycounts).

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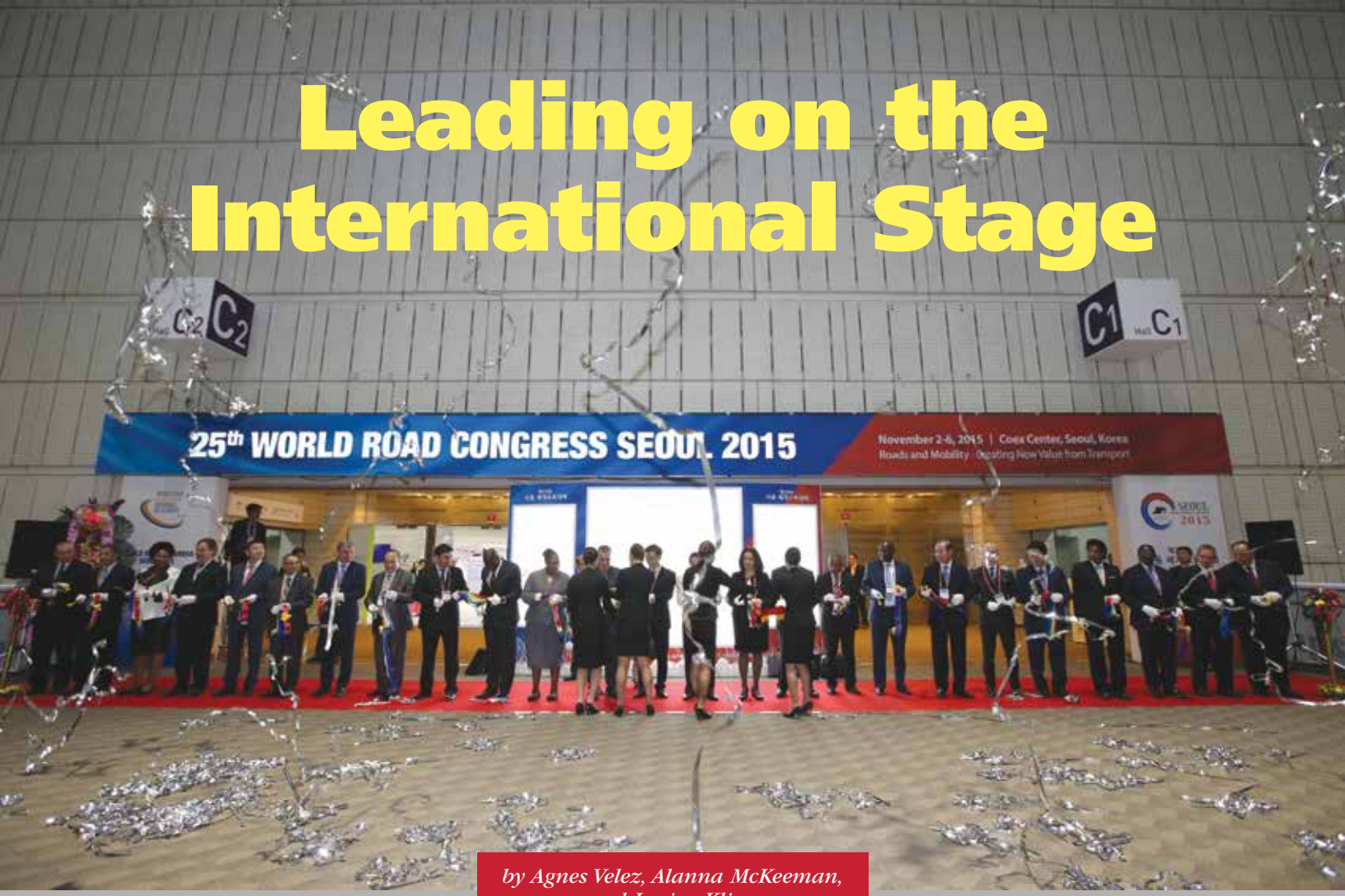
Leading on the International Stage



by Agnes Velez, Alanna McKeeman, and Jessica Klion

Through participating in the World Road Association, the U.S. transportation community has benefited from learning about research, practices, and technologies in other countries.

If you've ever been caught in a winter storm, you know what a difference it makes when crews clear roadways quickly and safely. But did you know that many of the practices and technologies used during winter storms in the United States to minimize storm impacts were developed in other countries?

There is no need to reinvent the wheel, and sharing research among State departments of transportation and between the Federal Highway Administration and State DOTs has become the norm. The benefits of receiving or imparting information about research and new practices are well recognized.

The same reasoning applies to U.S. participation and leadership in the World Road Association (WRA) (sometimes referred to as "PIARC," which stands for the organization's former name: Permanent International Association of Road Congresses).

Founded in 1909, the WRA is a network of road administrations from more than 120 countries that convene to share roadway-oriented research, practices, and technologies. As one of the world's leading organizations in the exchange of knowledge and technology transfer related to roadway transportation, the WRA addresses a vast range of topics and serves as a resource for developed countries with advanced road networks, as well as for developing countries.

For the United States, participation satisfies two purposes. First, the WRA provides an opportunity to learn from nations that employ advanced technologies and practices, including those in areas of strategic interest to the United States. Second, participation in the WRA enables U.S. representatives to share experiences and technical knowledge with other countries that can benefit, thereby supporting two-way exchanges of information.

The United States was a founding member of the WRA and has increased its participation significantly within the past decade, making a deliberate effort to become active in the association's technical and corporate bodies and leading and

(Above) Delegates and representatives from the World Road Association gathered to celebrate the beginning of the 2015 World Congress in Seoul, South Korea. *Photo: ©Korea Organizing Committee.*

contributing to a number of products and strategic initiatives. During this time, U.S. delegates to the WRA—who are generally transportation practitioners at the State and national levels—have used their participation to gather information and implement new technologies to benefit the U.S. transportation system and the traveling public that uses it.

Since 2008, U.S. involvement has included spearheading the development of internationally recognized flagship publications. Among these products are the *Road Safety Manual*, which was recently acknowledged by the United Nations as a highly significant effort aligned with the UN Decade of Action for Road Safety.

According to FHWA Executive Director Walter C. "Butch" Waidelich, Jr., the agency "intends to continue the deliberate, consistent, and active posture that has defined our participation [in the WRA] over the last two cycles."

How Is the WRA Organized?

The leadership bodies of the WRA include a council, an executive committee, and three commissions. The council is composed of delegates from member countries and has ultimate governance responsibility for the organization. The council elects the officers, members of the executive committee, and the general secretariat, which provides staff functions. The three commissions are responsible for strategic planning, finance, and communications.

In addition, approximately 40 member countries have national committees, which contribute to the dissemination of the organization's products, organize local activities, and undertake some membership and administrative services in their respective countries. The American Association of State Highway and Transportation Officials (AASHTO) has served as the U.S. National Committee to the WRA since 2011. In addition, the Transportation Research Board has a memorandum of understanding with the WRA that calls on the two organizations to work together to further their shared objective of advancing the state of the practice in roadway transportation.

For the past decade, FHWA has led and coordinated the participation of U.S. delegates in the WRA. The agency appoints the U.S.'s First Delegate, as the head of each national delegation is known, as well as U.S. delegates to the WRA's technical committees and task forces. Designation and assignment of FHWA representatives is made according to FHWA program priorities. The U.S. First Delegate is a position linked to the FHWA executive director. As First Delegate, the executive director has the final authority to determine U.S. policy positions within the WRA and final authority on how to cast votes on specific issues. FHWA also designates representatives to the World Road Congress, the WRA's major conference held every 4 years since 1908, and the International Winter Road Congress, a complementary WRA conference that has been held every 4 years since 1969.

WRA Areas of Study

The WRA operates on 4-year cycles, with each cycle guided by a new strategic plan with several strategic themes, each overseen by its own coordinator. In recent cycles over the past two decades, the strategic themes and other initiatives have related to management, finance, and performance; access and mobility; safety; infrastructure; and sustainability and resilience.

Nested within each strategic theme are technical committees, task forces, regional task forces, and special projects. A special project is a recently established method of project delivery promoted by the United States. Instead of relying entirely on delegates, who are generally volunteers, to develop products, the special products involve a method

Flagship Products

The WRA, with considerable U.S. leadership and assistance, has developed a number of flagship products, including the *Road Safety Manual,* the *Road Network Operations & Intelligent Transport Systems Guide*, and the *Snow and Ice Databook*. These publications were developed largely because of significant U.S. involvement and leadership. They are available on the WRA Web site, www.piarc.org, free of charge.

Published under the leadership of former FHWA Executive Director Jeff Paniati and with substantial technical input from FHWA's Michael Griffith, director of the Office of Safety Technologies, the *Road Safety Manual* is intended to help countries at all stages of development fulfill road safety objectives. Available online, the manual builds on information included in the first edition and advocates for a safe system approach, which aims at a more forgiving approach that takes human fallibility and vulnerability into account.

The *Road Network Operations & Intelligent Transport Systems Guide* is an online handbook that provides guidance to practitioners on the effective use of intelligent transportation systems in advancing the practice of road network operations. As one of the leaders in the field, the United States is well represented in the guide. FHWA's James Pol contributed significantly to the development of the WRA flagship product.

Rereleased every 4 years, the *Snow and Ice Databook* is one of the WRA's best known products. A number of U.S. representatives on the WRA's Winter Service Technical Committee have had a hand in developing various editions of the databook, including FHWA's Gabe Guevara and AASHTO's Rick Nelson.

The new *Road Safety Manual* is available at the WRA's Web site and is interactive.

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King Gee (right), director of engineering and technical services at AASHTO and U.S. National Committee secretary, represented the United States and the National Committee at the 2015 World Road Congress. Seated next to Gee is Dr. John Miles, a WRA honorary member.

of project delivery similar to that used by the National Cooperative Highway Research Program in the United States. Under this method, expert consultants, working under the direction of the leaders of the WRA's technical committees and corporate structures, develop the special projects. To date, the WRA has issued publications for two special projects. The first is *The Importance of Road Maintenance*, which draws on robust evidence of maintenance benefits from around the world. The second, the *International Climate Change Adaptation Framework for Road Infrastructure*, provides guidance to member countries that are seeking to adopt a consistent approach to analyzing the effects of climate change on their road networks to help identify and prioritize the most appropriate measures to mitigate the risks associated with extreme weather events.

Participation by U.S. delegates with domestic leadership positions, including former FHWA Executive Director Jeff Paniati, has enabled the United States to encourage the WRA's activities and research agenda to focus on topics of high strategic importance and interest to the U.S. transportation community—a role that current FHWA Executive Director Waidelich will continue in the 2016–2019 cycle. For example, the new strategic theme, Climate Change, Environment, and Disasters, is one of particular interest and high investment in the United States, and was added to the strategic plan for the 2016–2019 cycle. Freight is another issue of current strategic importance to the United States and is also represented in the 2016–2019 strategic plan.

As noted by Paniati, "The more invested FHWA is in long-term and continuous participation in the WRA, the higher the return on that investment will be. There is a significant amount of untapped potential for the U.S. to continue shaping the WRA agenda to advance the interests that the U.S. shares with partner countries."

Outcomes of U.S. Participation in Two Recent Cycles

Participation in the WRA has resulted in positive outcomes for U.S. delegates and their professional organizations. For example, participation in the 2008–2011 and 2012–2015 cycles enabled U.S. practitioners to offer their expertise in some areas and learn from foreign experts in others, thereby facilitating the benchmarking of domestic practice. In addition, it enabled U.S. representatives to build relationships and glean knowledge of practices related to policy and analysis, as well as tools and practices related to implementation for incorporation into domestic practices.

Benefits related to policy and analysis practices and methods were obtained in three key areas during the 2008–2011 and 2012–2015 cycles: asset management, economic analysis, and sustainability.

Asset management. Historically, U.S. understanding and implementation of the principles of asset management have lagged behind countries such as Australia, New Zealand, and the United Kingdom. Participation in the WRA, however, provided U.S. transportation practitioners with the opportunity to connect with international experts in order to understand how the principles of asset management could benefit the U.S. roadway system.

Steve Gaj, team leader of the FHWA Office of Asset Management, played an important role in demonstrating those benefits to Congress, based on experience and knowledge he gathered through participation in the WRA. In Gaj's communications with the Senate Committee on Environment and Public Works, he was able to cite information from foreign experts he met through the WRA regarding the development of asset management plans, life cycle planning, and asset valuation. His understanding of the cost and performance benefits of effective asset management were valuable as Congress included a requirement in the Moving Ahead for Progress in the 21st Century Act (MAP-21) for States to develop asset management plans for the first time.

Gaj says, "Learning from the experiences of other countries has enabled the United States to avoid reinventing the wheel and to understand the nuances associated with asset management."

According to FHWA, the investment in transportation assets owned and operated by public agencies at the Federal, State, and local levels totals more than $1.75 trillion. Therefore, the monetary savings that could be realized through implementation of effective asset management business processes and practices is immense. Many asset management practices are already used by utilities and private companies in other sectors to save money.

Economic analysis. Similarly, participation in the WRA has advanced U.S. practices in the economic analysis of transportation projects. In the United States, national-level economic analyses focus primarily on evaluating costs and benefits using the Highway Economic Requirements System and the National Bridge Investment Analysis System.

Other countries, such as Japan and South Korea, more commonly use ex post evaluation processes. These analyses evaluate the effectiveness and sustainability of a project, with a focus on identifying lessons learned and making recommendations for planning more effective and efficient projects or programs in the future.

As a member of the WRA's Road Transport System Economics and Social Development Technical Committee, Karen White, currently director of the U.S. Bureau of Transportation Statistics' Office of Statistical and Economic Analysis, assisted in the development of a report on ex post cost-benefit evaluations. It discusses the economic analysis practices of road agencies around the world and directly informed White's work in her previous position, in the FHWA Office of Policy and Governmental Affairs, on the *Conditions and Performance Report*, which is developed for Congress every 2 years. At FHWA, White examined ways in which the agency could restructure the report to Congress by using new tools to better measure the conditions and needs of the surface transportation system.

"The work that I conducted through the WRA provided me with an understanding of foreign practices, as well as sharing U.S. practices," says White.

The reimagined *Conditions and Performance Report*, still under development, may include economic analysis employing elements of the British system of program evaluation, which uses a policymaker-designed weighting system for measuring investment impacts.

The *Conditions and Performance Report* is one of USDOT's most significant opportunities to communicate to Congress and the Nation regarding the state and investment needs of the U.S. transportation system, and is widely cited as a leading source of information on this subject. As such, the ability to use more sophisticated analysis methods to better measure economic impacts enables USDOT to create a more sound and compelling case for the need, for example, to invest in the transportation system to support the Nation's economy.

As FHWA Administrator Gregory Nadeau has stated, "Every dollar produces results for the American people."

Sustainability. Through WRA participation, U.S. delegates also gathered information on sustainability-related policies and practices that have the potential to be—or, in some cases, have been—implemented in the United States. Through work he conducted on WRA's Freight Technical Committee, Bill Gardner, director of the Office of Freight & Commercial Vehicle Operations at the Minnesota DOT, learned how the United States differs from other countries in the emphasis placed on sustainability. Many European countries focus more heavily on sustainability in transportation activities in general. In addition, sustainability abroad tends to be the first screen in decisionmaking, whereas in the United States, it is sometimes considered as an afterthought. Some of the foreign practices that Gardner learned about through his work on the freight committee were relevant to his leadership role in developing the Minnesota Statewide Freight System Plan. For example, Gardner's research indicated that some countries integrate freight and land use systems to improve freight mobility and enhance economic development, focusing on preserving freight uses and industrial land. Similarly, a strategy included in Minnesota's freight plan focuses on land use planning and preservation.

Implementation-Related Practices and Tools

In addition to policies and analysis practices, U.S. delegates to the WRA have brought back to their agencies and professional organizations a variety of practices and tools related to implementation that were developed and tested abroad. In particular, there are examples of technology transfer related to winter maintenance, freight, and security.

Winter maintenance. The United States has gained significant technical knowledge in the field of winter maintenance through WRA participation. As Rick Nelson, coordinator of AASHTO's Snow and Ice Pooled Fund Cooperative Program (SICOP) and former Nevada DOT official, notes, "In the 1990s, in the winter

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Jeff Paniati, former executive director of FHWA, gave a presentation on the *Road Safety Manual* at the 2015 World Congress in Seoul, South Korea.

maintenance field, the U.S. was so far behind Europe that we thought we were ahead. We have closed the gap because of our participation on [WRA] technical committees."

Nelson and Gabriel Guevara, a transportation specialist with FHWA's Office of Transportation Operations Road Weather Management Team and also U.S. representative on the Winter Service Technical Committee, both contributed to the development of the WRA's 2014 *Snow and Ice Databook*. Rereleased every 4 years at the WRA's winter congress, the *Snow and Ice Databook* is the most comprehensive and widely consulted source of information about international practices in winter maintenance. It contains information about materials used, technologies employed, governance structures, and performance tracking. Practitioners and researchers in the United States have used several editions of the databook as a key resource in developing reports and plans.

Because of the publication's success, Nelson, who played a lead role in developing the U.S. section of the current edition, has considered creating a domestic version of the publication that could serve as a standalone product for use by States and local practitioners. The *Snow and Ice Databook* has had a significant impact on the U.S. winter maintenance community.

One example of a practice learned by U.S. representatives who serve on the Winter Service Technical Committee is anti-icing. Guevara notes that the United States learned about anti-icing through WRA technical committee interactions. For several decades, the U.S. focused on deicing—treating roads with salt after a weather incident. But much earlier, European countries had begun practicing anti-icing methods, in which they treated roads with a salt brine prior to snow and ice events.

Anti-icing is considerably more environmentally sustainable and uses approximately one-third of the resources in terms of materials, equipment, and labor, resulting in millions of dollars in cost savings as opposed to the deicing approach. According to FHWA's road weather management program, States spend $2.3 billion annually on winter maintenance, a large portion of which includes materials and labor, as well as millions to repair infrastructure damaged by snow and ice. Incremental improvements therefore have the potential to save millions when implemented.

April Marchese, director of FHWA's Office of Natural Environment, gave a presentation on the *International Climate Change Adaptation Framework for Road Infrastructure*, a flagship product that she had a lead role in developing.

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Through Nelson's participation on the technical committee, he gathered information from French and Swedish WRA delegates about sustainable salting practices. He shared those practices with the SICOP steering committee and incorporated sustainability into its work program. Through that work, information on sustainable salting practices was included in the sustainability checklist of the American Public Works Association. The checklist is heavily used by the Salt Institute, a trade association dedicated to advocating the benefits of salt, particularly to ensure winter roadway safety, water quality, and healthy nutrition. The Salt Institute now distributes a Safe and Sustainable Snowfighting Award that recognizes agencies that deal with snow removal in an environmentally and economically conscious manner.

Through WRA participation, U.S. practitioners have also learned about and employed techniques to upgrade equipment used to sand roads for winter maintenance. While attending a technical committee meeting, Nelson learned about a relatively common practice in Europe of attaching removable legs to trucks to apply sand to roads, a technology he brought back to the Nevada DOT and implemented.

The sanding equipment traditionally used in the United States requires winches to remove the sanders from the trucks, which is a somewhat laborious and dangerous process, costing significant time and money. The removed sanders then sit in an equipment yard for several months of the year, taking up valuable storage space. The removable legs are much safer, easier to take on and off, and are considerably smaller than traditional sanders, reducing costs for the Nevada DOT.

Freight. In addition to practices relating to winter maintenance, U.S. representatives have gleaned implementation practices related to freight. As a member of the WRA Freight Technical Committee, Minnesota's

Removable sander legs on a truck used in Germany save time and money. *Photo: Rick Nelson, AASHTO SICOP Coordinator.*

Courtesy of Michigan DOT and HNTB

This sign in Michigan on I–94 indicates available truck parking. Signs like this make it easier for truck drivers to find available parking, thereby reducing vehicle emissions and the time spent looking for parking.

Gardner learned from another committee member about a Dutch system for providing information on the availability of truck parking. Gardner used this information to supplement existing knowledge of similar systems. Subsequently, Minnesota collaborated with State DOTs from Indiana, Iowa, Kansas (the lead State on the grant), Kentucky, Michigan, Ohio, and Wisconsin, several of which also had previous experience with these systems, to apply for and win a $25 million Transportation Investment Generating Economic Recovery (TIGER) discretionary grant to implement a Regional Truck Parking Information and Management System (TPIMS).

According to FHWA Administrator Nadeau, "TPIMS will help improve trucker safety [by] using existing technology to distribute information to commercial drivers on truck parking capacity and current occupancy through smartphone apps, dynamic road signage, Web sites, and parking facilities."

Nadeau called the grant "one of our most innovative TIGER grants ever."

Security. The security of transportation infrastructure is another area in which the United States gathered information about international practices through WRA participation. In the U.S., the security of highway infrastructure is approached differently than in other countries, and the sensitive nature of infrastructure security-related discussions and strategies makes face-to-face interactions between WRA members quite useful for all. As a member of the WRA Task Force on Infrastructure Security, Steve Ernst, a structural engineer in FHWA's Office of Bridges and Structures, was able to build relationships with counterparts in France, Italy, the United Kingdom, and other countries. From counterparts in the U.K., Ernst learned about the use of street barriers that protect facilities from explosive devices and provide exclusion capability. Road barriers are designed to protect drivers and vehicles from customary geometric conditions on highways, and there are U.S. Department of Defense criteria (Unified Facilities Criteria) for barriers that address anti-terrorism protection requirements. The U.K. developed and tested systems against a wide range of threats across both regimes, including threats that require protection against impact loads to exclude vehicles from an area and protection from blast loads and fragments. Ernst is now working with the Volpe Center to explore implementing similar barrier technologies in the United States.

Relationship Building

In addition to gathering information, participation in the WRA enables U.S. representatives on technical committees to develop relationships with counterparts in other countries. They are then able to contact those professionals when they want information on specific topics, approaches, lessons learned, and technologies—particularly information that goes beyond what one can learn from reading publications.

These connections enable additional collaboration outside of the WRA, not only with technical committee members, but also with other individuals within the members' organizations. As multiple U.S. members of technical committees have noted, when they have something they want to learn about in another country, they immediately have someone they can call—and that someone often can refer them to someone else who is just the right contact.

Gardner, for example, explains that his WRA participation provides, in addition to other benefits, an opportunity to exchange best practices with freight leaders from around the world, including both developed and developing countries. "This helped me benchmark our own program for freight planning and implementation activities," Gardner says.

Similarly, Robert Ritter, safety programs team leader at FHWA and a member of the WRA National Road Safety Policies and Programs Technical Committee, noted that his committee is chaired by one of Sweden's experts on its Vision Zero initiative for traffic safety. "Participation on the committee provided me with direct access to a leading expert on a topic important to the United States," says Ritter, "and enabled me to be a better resource for the U.S. on Vision Zero strategies."

Scot Becker, director of the Bureau of Structures at the Wisconsin DOT, used connections he formed through participation on the WRA Road Bridges Technical Committee to get advice from a range of experts when a bridge in his State started to sink. Becker says, "Gathering advice and information from foreign experts helped me figure out how it could be repaired."

Similarly, Becker was also able to obtain specifications from other countries that provided him with valuable information about strategies used to prevent the degradation of bridge decks. Some of this information was incorporated into

strategies employed in Wisconsin to extend the life of bridge decks, resulting in cost savings for his agency and taxpayers.

Participation in the WRA enables U.S. delegates to interact not only with counterparts from governments abroad but also with representatives from the private sector and academia, whose participation is a practice more common outside the United States. As a result, U.S. technical committee members gain exposure to foreign experts whom they might not have otherwise met through agreements that USDOT makes to collaborate with public agencies abroad.

As a member of the Road Network Operations/Intelligent Transportation System Technical Committee, FHWA's James Pol, technical director of the Office of Safety Research and Development, noted that WRA participation enabled him to connect with a broad array of international experts. Formerly a team leader in FHWA's Intelligent Transportation Systems Joint Program Office, Pol regularly interacted with international partners. For example, the Joint Program Office has a trilateral agreement with equivalent agencies in the European Union and Japan to share research. Members of Pol's WRA technical committee, however, were largely from the private sector and academia, meaning that he was able to forge relationships with individuals outside the government sphere and gain access to additional information and perspectives.

Other Benefits

Additional positive outcomes of U.S. participation in the WRA include streamlined international engagement with multiple countries and increased employee satisfaction and engagement, as well as a mechanism to help give back to the worldwide transportation community. Participation in the WRA facilitates consistent and meaningful interactions between U.S. practitioners and their international counterparts in both the public and private sectors, and works to complement formal international country-to-country engagements that FHWA already has or is pursuing.

Many WRA delegates from the United States note the personal and professional benefits of participation. Paniati, who also served as the U.S. First Delegate to the WRA, notes that the opportunity to be involved in the WRA can be a strong retention tool for employees.

The *Road Network Operations & Intelligent Transportation Systems: A Guide for Practitioners* is available on this WRA Web site.

FHWA Associate Administrator for Safety Beth Alicandri; Director of FHWA's Office of Safety Technologies Michael Griffith; and many other delegates have commented on the rewarding and reenergizing nature of participation on WRA technical committees.

Future Opportunities

Clearly, WRA participation brings a host of benefits to the U.S. transportation community. One focus of the FHWA Office of International Programs, and its partners AASHTO and TRB, is to continue to actively look for and implement ways to increase the positive outcomes of participation by disseminating information to transportation practitioners throughout the country. These three partners also look to collaborate with other domestic transportation organizations to promote the awareness and use of WRA products.

The following opportunities exist for better dissemination of WRA products and the outcomes of U.S. participation:

- Creating earned media and social media plans to support the dissemination of publications
- Spotlighting member achievements
- Taking advantage of U.S. conferences and other events to disseminate information
- Expanding communication channels
- Making information available and easy to find online
- Implementing and building on the practices that have been successful for other WRA national committees
- Growing existing partnerships

Using these strategies will enable the results of U.S. participation in the WRA to reach a broader audience and ultimately bring even greater benefits to the U.S. transportation community.

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Making Every Place Count

Workshops hosted by USDOT found context-sensitive solutions to reconnect communities previously divided by highway infrastructure.

by Camille Bonham and Corbin Davis

In the mid-20th century, State departments of transportation constructed thousands of miles of interstates and other roads under President Dwight D. Eisenhower's Federal-aid Highway Program. Today, it is clear that this massive expansion of infrastructure at times bifurcated and bypassed communities, creating physical barriers between residents and essential social and economic opportunities.

Citizens of some communities are affected by poor land use planning and insufficient redundancy in local roads that provide alternative routes. As a result, they are cut off from jobs, schools, medical care, grocery stores, public transit, and other services and opportunities essential for well-being and full participation in society. For these residents, increased distance and travel time to services pose a significant inconvenience, and the vehicle-centric environment in which they live presents a host of threats to the safety of pedestrians and bicyclists. Such limitations to mobility particularly affect vulnerable populations, including the young, older adults, and persons with disabilities.

To address the present-day consequences of this history, U.S. Secretary of Transportation Anthony Foxx and the U.S. Department of Transportation created an initiative called Ladders of Opportunity. This initiative encourages investment in transportation policies and projects that improve connectivity, provide access to economic opportunity for traditionally underserved populations, and create workforce development programs to grow and support the U.S. middle class. In leading the Ladders of Opportunity initiative, USDOT has acknowledged that "there is a regrettable legacy of aligning and designing transportation projects that separated Americans along economic and even racial lines."

The timing of the initiative is crucial. Because much of the Nation's infrastructure is in need of repair or replacement, restorative improvements provide opportunities for considerations of inclusivity and accessibility in upcoming projects and policies.

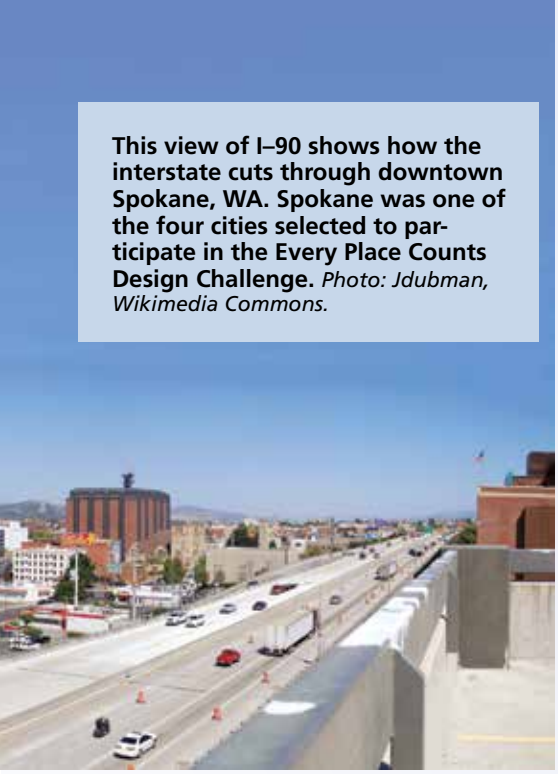
Citing the Long Street Bridge in Columbus, OH, as an example of restorative design, Secretary Foxx said the project restored connection between the King-Lincoln District, a neighborhood that was cut off from the city's center and economic opportunity in the 1960s by construction of an interstate highway. "This effort to reconnect and revitalize a community divided by past transportation policies," Foxx said, "is a compelling example of how transportation can create or eliminate opportunity gaps in our Nation."

Recognizing the potential of transportation infrastructure to transform and revitalize neighborhoods, Secretary Foxx and USDOT also created the Every Place Counts Design Challenge. This challenge is a component of the Ladders of Opportunity initiative and is intended to help communities redesign transportation infrastructure that poses physical barriers and enhance access to essential services.

Design Sessions In Four Cities

In May 2016, USDOT solicited proposals from local and tribal governments for projects to improve or replace existing transportation infrastructure that adversely affects their communities. The Every Place Counts Design Challenge offered technical assistance in the form of 2-day charrettes—place-based, intensive brainstorming workshops to discuss residents' needs and develop innovative, restorative, and context-sensitive designs. The charrettes covered topics ranging from design, architecture, and engineering strategies to funding programs and the Federal processes for transportation planning, programming, and the National Environmental Policy Act reviews.

In response to its solicitation, USDOT received 34 proposals. In the interest of geographic diversity, USDOT selected four awardees from various regions of the country: Nashville, TN; Philadelphia, PA; Spokane, WA; and



This view of I–90 shows how the interstate cuts through downtown Spokane, WA. Spokane was one of the four cities selected to participate in the Every Place Counts Design Challenge. *Photo: Jdubman, Wikimedia Commons.*

At the Philadelphia charrette, this discussion leader is drawing a visual that explains the purpose of the Every Day Counts Design Challenge. *Photo: Joseph Gidjunis, © City of Philadelphia.*

St. Paul-Minneapolis, MN (Ramsey County). During July 2016, USDOT held a charrette in each city.

Secretary Foxx has said, "We need to make sure our infrastructure design is as inclusive as it can be."

Accordingly, the four selected cities convened community teams to participate in the charrettes. The teams included elected officials, planners, transportation and design professionals, and a cross section of community residents. Additional attendees included representatives from the Federal Highway Administration, State departments of transportation, public works departments, and local academic institutions, as well as mayors, land and business owners, developers, artists, and activists. Also in attendance to facilitate and contribute expertise were USDOT contracted staff from the Congress for the New Urbanism, a national nonprofit organization that plans and promotes vibrant, walkable cities and encourages highways-to-boulevards projects, and the Toole Design Group, a planning and landscape architecture firm with a focus on bicycle and pedestrian infrastructure.

The first day of each city's charrette included a group tour of the area affected by the infrastructure challenge in question, presentations by facilitators about strategies and designs used in other communities to resolve similar challenges, and group discussion. On the second day, stakeholders described the needs they perceived in their communities and worked together to problem-solve and propose solutions. The contractors then created visuals based on participants' comments and reflected the collaborative designs back to the group.

"A lot of times we [USDOT leaders] get caught up at the policy level," says David Howard, associate administrator for policy and governmental affairs at FHWA, reflecting on the meaning of the design sessions. Howard attended charrettes in Minneapolis and Philadelphia. "It's time for us to go out to the street level. I think out there, you start to see how some of these issues came to be, how complex they are, and what it will take for them to heal."

Nashville, Philadelphia, Spokane, and St. Paul-Minneapolis are as different in the transportation solutions they seek as they are in community character. Therefore, each charrette was a tailored event in which participants voiced frustrations and hopes specific to their cities' histories. The following synopses outline the challenges and potential solutions explored in each city.

Nashville

The construction of I–40 in Nashville divided a thriving middle-class African-American community, which affected access to businesses, a world-class local music scene, and three nearby historically black colleges and universities. Residents expressed concern that planned improvements to the I–40 corridor could hasten gentrification. Participants at the well-attended charrette also expressed a desire to

The Dale Street Bridge over I–94 in Ramsey County, MN, shown here, is where the Minnesota Department of Transportation is planning a reconstruction project. *Photo: USDOT.*

A participant at the Nashville charrette is drafting a visual of a roundabout to replace one of the intersections along the city's Jefferson Street Corridor. *Photo: USDOT.*

explore design solutions while safeguarding the community from demographic shifts and ensuring that residents could continue to afford living in the area if the proposed neighborhood improvements resulted in increases in property values.

One attendee, describing residents' preference for balancing infrastructure improvements with the continuity and integrity of Nashville's character, said, "This community is not interested in placemaking—we're interested in 'placekeeping.' Let's open ourselves to the possibilities that arise from meeting the needs of the community, from supporting cohesiveness. We can 'do transportation,' but in a way that's *more*."

The participants at the Nashville charrette developed designs for a number of potential improvements to their community, including new bicycle lanes and transit routes, increased parking, context-sensitive infill opportunities, conversions of interchanges to roundabouts, and reconnections of local roads in the Jefferson Street Corridor to downtown Nashville by capping (building a roof-like structure atop a sunken highway) a portion of I–40 near Dr. D.B. Todd Jr. Boulevard. The corridor is a central connection to the city's black higher educational system, as well as one of the city's historic music districts, where many venues and businesses closed following the construction of I–40.

Philadelphia

I–676 is a depressed limited-access highway through center city Philadelphia. When it was being constructed, I–676 was heralded a cutting-edge project that included multiple bridges and plantings. Following Secretary Foxx's attendance at the Philadelphia charrette, he described the repercussions of constructing the highway: "Three communities . . . bore the brunt of the damage as many homes, businesses, schools, places of worship, and other places of cultural and community significance were razed to make way for the expressway. Presently, the Vine [Street] Expressway is a six-lane corridor not easily navigated [over or around] on foot or in vehicle, and represents a very real, physical barrier for those [who] must traverse it daily."

The city of Philadelphia stated in its application for the Every Place Counts Design Challenge that, because of the expense of capping (or even partially capping) the Vine Street Expressway, creative design solutions are necessary to incorporate the corridor affordably into the city grid and reconnect blighted neighborhoods to area schools, hospitals, and other services.

Charrette participants collaborated to develop numerous designs, including the conversion of underused parcels into green space or mixed-use developments, improved pedestrian crossings, stormwater planters, bike lanes and a bike-share station, as well as other solutions.

Seated toward the center of the table's left-hand section, Secretary Foxx is gesturing during discussion at the Philadelphia charrette. *Photo: City of Philadelphia.*

Spokane

In Spokane, planners already were designing several restorative projects, including a limited-access freeway and a bicycle corridor, when the city applied to the Every Place Counts Design Challenge to seek USDOT assistance to maximize the positive effects of the projects. In its application, the city wrote that the charrettes could "elevate the community visioning process" during efforts to improve connectivity along I–90, the construction of which had bifurcated the working-class neighborhood of East Central, and also along the new North Spokane Corridor.

Charrette participants, including residents, city officials, and representatives from the U.S. Department of Agriculture, the U.S. Environmental Protection Agency, and the National Endowment for the Arts, followed through on the application's promise by envisioning and developing several bold designs. One design includes a land bridge over I–90 and the conversion of the North Spokane Corridor into a boulevard.

St. Paul-Minneapolis

Charrette participants in St.Paul-Minneapolis contributed substantial knowledge about planning and design processes to the conversation with visiting experts about possible solutions to the problems created by I–94. The construction of I–94 divided the Twin Cities' Rondo neighborhood, the area's largest African-American community. The area has since become highly diverse: the homes of African-American, Asian-American, and Native American families now line the highway.

A group tour of I–94 during the charrette made clear to visiting USDOT officials and planners that the neighborhoods surrounding the interstate contend with a car-centric environment that lacks safe pedestrian crossways. Existing crossways are sparse and uninviting, but the area along the highway is punctuated by vacant lots that residents envision as potential green space. Charrette participants also sought

multimodal solutions to reconnect communities around I–94, expressing particular interest in bicycle and pedestrian crossings. In addition, participants proposed the replacement of intersections with roundabouts, land bridges, and, with assistance from the USDOT contractors, developed designs for several new parks.

Like the Nashville stakeholders, the St. Paul-Minneapolis group valued local history and proposed a context-sensitive design for commemorative plazas featuring the neighborhoods affected by I–94. Highlights of the charrette included speeches by St. Paul and Minneapolis mayors Chris Coleman and Betsy Hodges, respectively, who acknowledged the social and cultural effects of infrastructure challenges in the Twin Cities and emphasized government responsibility to the people, especially underserved populations.

Looking Ahead

Not all of the designs developed during the charrettes are financially feasible in the near term, and solutions preferred by residents sometimes conflicted with the purpose of the interstate network as essential to the Nation's economy and defense. Nevertheless, the workshops succeeded in bringing together diverse stakeholders, honoring the needs expressed by community members and engaging in a collaborative effort among parties that often operate independently.

"It's been a good opportunity to develop partnerships," commented one charrette participant. "And it's been a good opportunity to pause for a minute and consider our community."

The Every Place Counts Design Challenge serves as a first step in USDOT's efforts to develop a model for new, more inclusive public engagement practices. The new model may include strategies such as incorporating public engagement earlier in project life cycles and providing greater opportunities for residents of areas affected by transportation projects to offer substantive input about project design.

Later in 2017, USDOT will release a report documenting and drawing on the four workshops. The report will include best practices, regional case studies, design guidelines, and consensus-building strategies for addressing community infrastructure impediments through urban design. Also, the Federal Highway Administration will incorporate the lessons learned through the Every Place Counts Design Challenge into its Every Day Counts (EDC-4) Community Connections initiative, which focuses on the value of transportation in community revitalization. FHWA's EDC-4 will provide technical assistance, training, and resources to facilitate the discussion of highway retrofitting, rehabilitation, or removal options to improve connections between urban cores and neighboring communities.

"There won't be fast solutions," says FHWA Associate Administrator Howard. "But I think and hope that all the stakeholders that were involved will fight hard to deliver. We're trying to address some of the trust issues, not just the infrastructure issues, that have come up over the past decades. We're trying to heal the dynamic between the government and the public by developing better engagement strategies. The charrettes are over, but this isn't the end; it's the beginning."

Camille Bonham is a transportation specialist with FHWA's Office of Planning, Environment, and Realty. She studied international development and fine art at Grinnell College, and she is currently earning a master's degree in urban and regional planning from Georgetown University.

Corbin Davis is a community planner with FHWA's Office of Planning, Environment, and Realty. Davis received a master's degree in urban and environmental planning from the University of Virginia and a bachelor's degree in geographic science from James Madison University.

For more information, see www.transportation.gov/opportunity/challenge. Or, contact Camille Bonham at 202-366-6798 or camille.bonham@dot.gov, or Corbin Davis at 202-366-6072 or corbin.davis@dot.gov.

Participants at the Spokane charrette envisioned a land bridge over I–90, as shown in this rendering, to improve community connectivity. *Photo: USDOT.*

This digital image shows a design by the charrette participants for a full cap of I–94 in the Twin Cities' Rondo neighborhood, adding an abundance of green space. *Photo: USDOT.*

Preparing for Change

by Heather Holsinger

Improving the resilience of transportation infrastructure to a changing climate involves integrating preparations throughout the decisionmaking process from planning to design, construction, and beyond.

Will your State's transportation infrastructure be affected by the impacts of climate change? If so, how resilient will it be? Officials at the Federal Highway Administration want to help you answer these questions.

The risks associated with climate change and extreme weather events have emerged as significant concerns for the transportation sector in the United States and around the world. The impacts of a changing climate—higher temperatures, rising sea levels, and changes in seasonal precipitation—are already affecting transportation systems and are expected to intensify. Extreme weather, including heat waves, wildfires, drought, flooding, tropical storms, storm surges, and heavy downpours, have the potential to become more frequent and severe as the climate changes, damaging transportation infrastructure and resulting in loss of service and expensive repairs.

"Although transportation infrastructure is designed to handle a broad range of impacts based on the historic climate," says Michael Culp, team leader for sustainable transport and climate change in FHWA's Office of Natural Environment, "preparing for uncertainties in a changing climate is prudent to protecting the safety and integrity of the transportation system and the people it serves."

To better understand the risks of climate change, FHWA is working with its international, State, and local partners. The purpose is to develop tools and approaches to address these risks during all aspects of transportation decisionmaking—from planning and project design to construction, maintenance, and operations.

Read on for highlights of this ongoing work and some anticipated next steps.

The National Policy Context

In October 2009, President Obama signed Executive Order 13514 (Federal Leadership in Environmental, Energy, and Economic Performance) establishing the foundation for coordinated action on climate change preparedness and resilience across the Federal Government. The order directs all Federal agencies to develop climate adaptation plans and policies. Then

Hurricane Sandy caused this significant flooding at Battery Park Underpass in New York City. Climate change could lead to increased flooding from storm surges in coastal cities as sea levels continue to rise. *Photo: NYCDOT.*

in June 2011, the U.S. Department of Transportation released a Policy Statement on Climate Change Adaptation, directing the USDOT modal administrations to incorporate consideration of climate adaptation into their planning processes and investment decisions.

Building on the agency-level planning and action required by Executive Order 13514, President Obama issued Executive Order 13653 (Preparing the United States for the Impacts of Climate Change) in November 2013. This order directs Federal agencies "to improve the Nation's preparedness and resilience" by promoting "(1) engaged and strong partnerships and information sharing at all levels of government; (2) risk-informed decisionmaking and the tools to facilitate it; (3) adaptive learning, in which experiences serve as opportunities to inform and adjust future actions; and (4) preparedness planning."

Additional executive orders and guidance documents have followed, addressing climate change in specific sectors or through the actions of Federal agencies. For example, the White House Council on Environmental Quality released guidance in August 2016, describing how Federal departments and agencies should consider climate change adaptation in their National Environmental Policy Act reviews. Also, Executive Order 13690, issued in January 2015, established a Federal Flood Risk Management Standard with the goal of ensuring that federally funded buildings and infrastructure are sited and designed to be resilient to future conditions.

Understanding the Risks to Transportation Infrastructure

Since the early 2000s, FHWA has been working to better understand the potential impacts of climate change on the Nation's transportation system. The initial efforts involved exploratory white papers and workshops followed by in-depth regional studies on the impacts of climate change on the Atlantic and gulf coasts. This research made it clear that one of the more difficult aspects of understanding the risks is obtaining and applying the relevant climate information in the format needed for transportation planning and design. To address this issue, FHWA initiated a number of projects to develop tools and technical assistance to help transportation agencies use relevant climate information to assess vulnerabilities specific to their State or region.

For example, the gulf coast project, in its second phase, focused on the metropolitan planning organization (MPO) region of Mobile, AL. The purpose of this focused study was to evaluate which components of the transportation infrastructure are most critical to economic and societal function in the region, and assess the vulnerability of these components to weather events and long-term changes in climate.

The study's researchers also developed tools and approaches that transportation officials everywhere can use to determine which systems most need to be protected, and how best to adapt infrastructure to the potential impacts of climate change.

In 2010–2011 and again in 2013–2015, FHWA partnered with additional State DOTs and MPOs to conduct vulnerability assessments. The purpose of these pilots was to help the participating transportation agencies identify vulnerable assets and analyze options for adapting and improving their resiliency. Five teams participated in the first round of pilots, and 19 in the second round. The experiences and lessons learned from the first round helped inform FHWA's Climate Change & Extreme Weather Vulnerability Assessment Framework, a guide designed to help transportation agencies to conduct vulnerability assessments. Currently, FHWA is updating and expanding this framework based on the results and lessons learned from the second round of pilots.

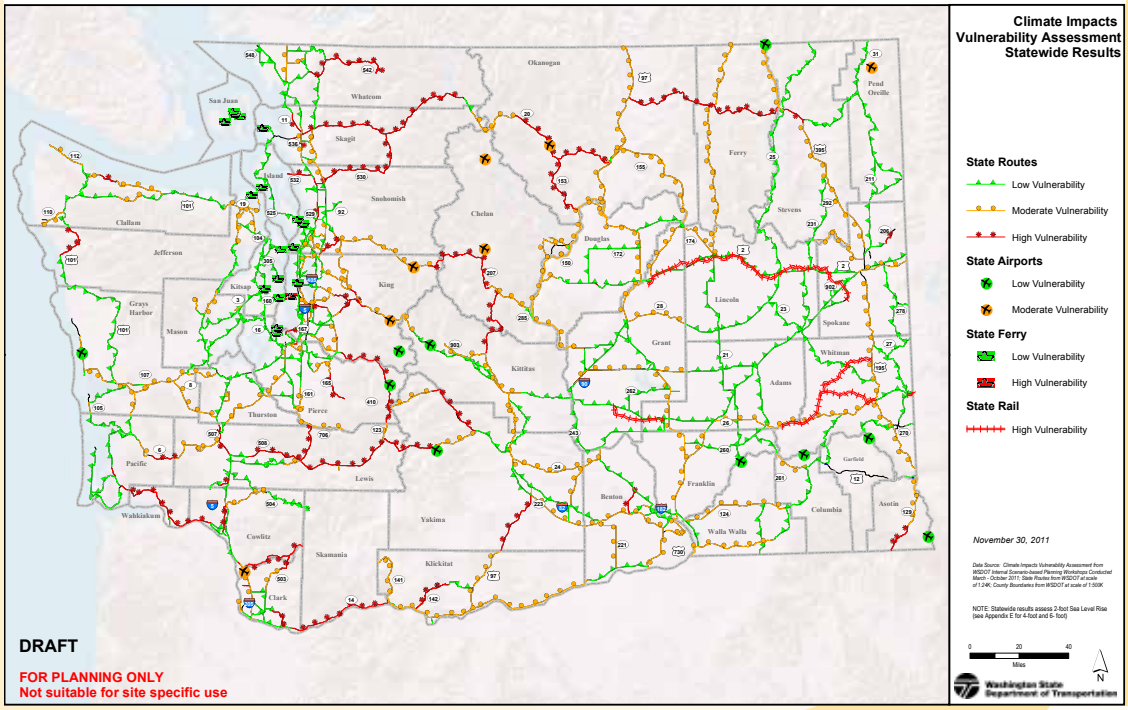
Moving From Knowledge to Action

Working with State DOTs and MPOs to assess the vulnerability of their transportation infrastructure to climate change remains a priority. Increasingly, however, FHWA is focusing on the integration of climate change vulnerability and risk into all aspects of transportation decisionmaking. In December 2014, FHWA issued Order 5520: Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events. The order establishes FHWA policy on preparedness and resilience to climate change and extreme weather events.

It also serves to comply with Executive Order 13653 and to further the USDOT Policy Statement on Climate Change Adaptation. FHWA Order 5520 states: "Climate change and extreme weather events present significant and growing risks to the safety, reliability, effectiveness, and sustainability of the Nation's transportation infrastructure and operations."

Order 5520 directs the agency to integrate consideration of the risks of climate change and extreme weather impacts and adaptation responses into the delivery and stewardship of the Federal-aid and Federal Lands Highway programs.

Vulnerability of WSDOT's Transportation Assets



The Washington State Department of Transportation (WSDOT) developed this map of the State showing road segments that have a high, medium, or low vulnerability to climate change. To develop the map, the agency held workshops with maintenance and engineering staff in all regions of the State, asking, "What happens if the climate-related conditions get worse?" Leveraging the knowledge of local staff, the agency also used GIS overlays of climate and asset management data, FHWA's Climate Change & Extreme Weather Vulnerability Assessment Framework, and climate data from a local university. *Source: WSDOT.*

The order includes a number of specific responsibilities, including developing and providing technical assistance to State DOTs, MPOs, and others in conducting vulnerability assessments. Other responsibilities include encouraging risk-based and cost-effective strategies to minimize climate and extreme weather risks to transportation infrastructure and updating planning, engineering, and operations guidance to include consideration of climate change and resilience to extreme weather events.

Planning for Climate Resilience

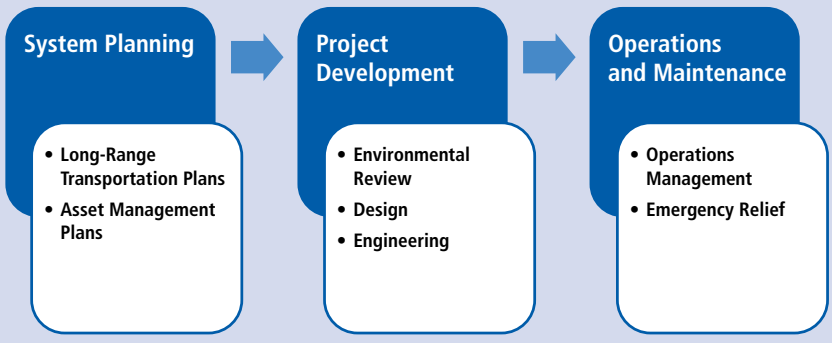
Transportation planning processes are comprehensive frameworks for making investment decisions and represent an important opportunity to consider climate change. Going forward, State DOTs and MPOs will be required to take resiliency needs into consideration in their planning processes, as a result of recent changes to transportation law.

The Fixing America's Surface Transportation (FAST) Act, signed into law on December 4, 2015, expands the scope of the metropolitan planning process to "improve the resiliency and reliability of the transportation system." It also requires that metropolitan transportation plans contain strategies that "reduce the vulnerability of the existing transportation infrastructure to natural disasters." For the statewide transportation planning process, the FAST Act expands the scope of consideration to include projects, strategies, and services that will improve the resiliency and reliability of the transportation system.

Some transportation agencies already have begun to consider climate change in their planning processes. For example, members of the MPO of Hillsborough County in Florida, as part of their participation in FHWA's 2013–2015 pilot projects, identified cost-effective strategies to mitigate and manage the risks of coastal and inland inundation. The purpose was to incorporate those strategies into the Hillsborough MPO's 2040 long-range transportation plan and other transportation planning and decisionmaking processes. The pilot project looked at several critical assets in the region and evaluated mobility and economic impacts if any of those facilities were to be out of service. Gandy Boulevard, part of an important link between Hillsborough and neighboring Pinellas County, was one of the assets evaluated.

The pilot project identified a 0.38-mile (0.6-kilometer) segment

Integration of Climate Change Into Transportation Decisionmaking



Source: FHWA.

on Gandy Boulevard between the Selmon elevated expressway and the raised Gandy Bridge as a critical hurricane evacuation route from adjacent Pinellas County. Following the pilot project, the Hillsborough MPO coordinated with the Tampa Hillsborough Expressway Authority, the owner of the facility, to conduct a followup study. The study looked at additional risk evaluations specific to the vulnerable segment, refining strategies and providing conceptual designs and pre-engineering cost estimates to offer low-risk, high-benefit solutions for implementation. The followup assessment suggests that the approximately $1.9 million adaptation strategies recommended would show a positive return on investment compared to the more than $3 million cost to replace the facility.

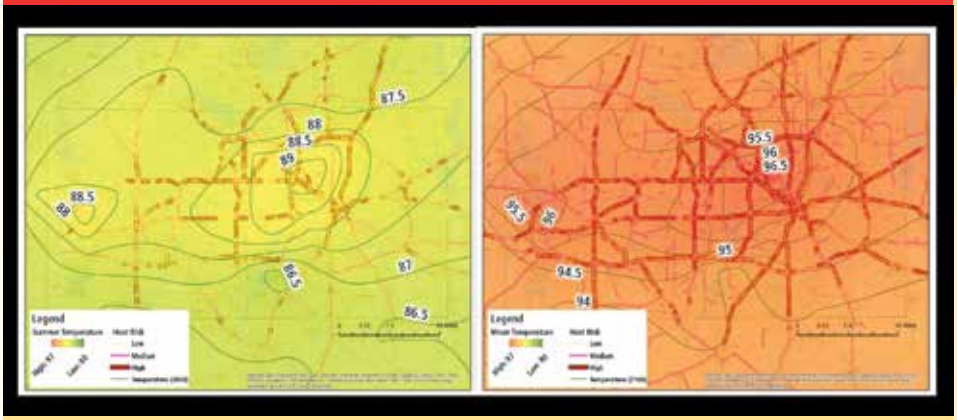
State DOTs increasingly use asset management plans to make decisions about where and when to invest State and Federal funds in infrastructure improvements to achieve a state of acceptable repair over the life cycle of transportation assets—representing another key opportunity for considering climate change. The Moving Ahead for Progress in the 21st Century Act (MAP-21) requires States to develop risk-based asset management plans for the National Highway System. In addition, MAP-21 section 1315(b)(1) requires the evaluation of reasonable alternatives for roads, highways, or bridges that repeatedly require repair and reconstruction activities.

On October 24, 2016, FHWA published a notice of final rulemaking in the *Federal Register* describing the process for developing these State risk-based asset management plans. That process includes addressing risks associated with current and future environmental conditions, including extreme weather events, climate change, seismic activity, and risks related to recurring damage and costs as identified through the evaluation of facilities repeatedly damaged by emergency events.

Transportation agencies already are exploring ways to integrate climate change risks into their asset management systems. For example, the North Central Texas Council of Governments participated in the most recent round of FHWA pilot projects on a study to assess how future climate will affect existing and planned transportation infrastructure. The study focused on roads, passenger rail, and the 19 airports in Dallas and Tarrant Counties. In recognition of a substantial anticipated change in demand for transportation infrastructure, the project team evaluated the vulnerability of both current and projected mobility and decided to focus the analysis on extreme heat, rainfall and flooding, drought, and the urban heat island effect. The council plans to use the results of the pilot study and proposed strategies to improve the links between asset management and infrastructure resiliency in both project-level and metropolitan transportation planning processes.

"There is a widely known saying that 'everything is bigger in Texas,'" says Jeffrey Neal, program manager at the North Central Texas Council of Governments (NCTCOG). "While the Dallas-Fort Worth Metroplex has consistently been the fastest growing metropolitan region in the United States for the past 5 years, the area has also experienced the tail end of one of the worst multiyear droughts in modern history, several crippling ice storms, the hottest summer on record, and the wettest year on record. The impacts and consequences to the regional transportation system are such that NCTCOG must work with providers and local governments to achieve an appropriate balance between expansion and preservation, because the pursuit of one without the other in mind will ultimately prove to be unsustainable."

Heat Risks Projected in North Central Texas



The map on the left shows heat risks in 2050, and the map on the right shows expected heat risks in 2100. Significant future increases in temperature will accelerate pavement degradation, rutting, and joint failures. The North Central Texas Council of Governments will use this information in long-range planning and asset management. *Source: NCTCOG.*

Adaptation at The Project Level

Given the long lifespan of many transportation assets, decisions made today related to the redesign and retrofitting of existing infrastructure, or design of new transportation infrastructure, will affect how resilient the system will be far into the future. To better understand how to account for the impacts of climate change in project development, FHWA is conducting a series of engineering-informed adaptation studies across multiple projects, asset types, and locations.

With the Transportation Engineering Approaches to Climate Resiliency Study, FHWA is refining a multistep process that was first developed under the second phase of the gulf coast project. The new study includes nine engineering-informed case studies of climate vulnerability and adaptation for specific highway facilities across the country. FHWA officials anticipate that the study will be completed in spring 2017.

Several of the 2013–2015 climate resilience pilots included project-level analyses. For example, the Minnesota Department of Transportation (MnDOT) looked at future precipitation and flood risk in developing and evaluating options for hydraulic facilities such as

culverts. To evaluate options for two culverts due for replacement in the near term, MnDOT used the multi-step engineering process developed during the gulf coast study. For a culvert on Silver Creek, MnDOT included input from climate models and determined that a slightly larger structure would be most cost effective in the long term when considering potential future damages.

In 2014, FHWA published *Hydraulic Engineering Circular No. 25–Volume 2—Highways in the Coastal Environment: Assessing Extreme Events* (HEC-25, Vol. 2; FHWA-NHI-14-006). The publication provides technical guidance on how to incorporate extreme events and climate change into coastal highway designs, with a focus on sea level rise, storm surge, and wave action. The circular includes case studies and examples of methods at three levels of effort to reflect projects of different magnitudes. The publication is available at www.fhwa.dot.gov/engineering/hydraulics/pubs/nhi14006/nhi14006.pdf.

In June 2016, FHWA released a similar update to *Hydraulic Engineering Circular No. 17–2nd Edition—Highways in the River Environment: Floodplains, Extreme Events, Risk, and Resilience* (HEC-17; FHWA-HIF-16-018). It provides technical methods on how to incorporate floodplain management, risk, extreme events, resilience, and adaptation for highways in the riverine environment. The guidance in the manual draws on the best actionable engineering and scientific methods and data. The publication is available at www.fhwa.dot.gov/engineering/hydraulics/pubs/hif16018.pdf.

Transportation Operations And Maintenance

Climate change and extreme weather events threaten the ability of transportation agencies to effectively manage, operate, and maintain a safe, reliable transportation system. For example, transportation agencies currently develop maintenance plans using historic climate information. Because of climate change, assumptions regarding the timing of freeze/thaw cycles, snow melt, vegetation growth, rates of weather-related degradation, and optimal times for construction work might need to be revisited.

For culvert 5648, shown here, which carries MN–61 over Silver Creek in Minnesota's Arrowhead Region, the State used input from climate models indicating that a slightly larger replacement structure would be more cost effective in the long term. *Photo: MnDOT.*

FHWA's *Climate Change Adaptation Guide for Transportation Systems Management, Operations, and Maintenance* (FHWA-HOP-15-026) provides specific guidance for integrating climate change adaptation and extreme weather responses into management operations and maintenance programs. For many of the already observed and anticipated weather events related to climate change, operations and maintenance workers, as well as the State DOT emergency responders with whom they coordinate, are the front line of the response. If agencies do not understand the risk to their operations, they can be caught off guard by an unexpected event, leading to significantly degraded capabilities when they are most needed. Additional

Learning From a Disaster

Hurricane Sandy hit portions of the northeastern United States in October 2012. The storm was the largest Atlantic hurricane on record, as measured by diameter, with winds spanning 1,100 miles (1,770 kilometers). The hurricane caused significant loss of life as well as tremendous destruction of property and critical infrastructure.

In the aftermath of the storm and building on one of FHWA's 2011 pilot projects in New Jersey, FHWA initiated the multimodal study Hurricane Sandy Follow-up Vulnerability Assessment and Adaptation Analysis. The study involves a large number of stakeholders, including State DOT and MPO partners in Connecticut, New Jersey, and New York, as well as the Metropolitan Transportation Authority, Port Authority of New York & New Jersey, and others.

The study leverages lessons learned from Hurricane Sandy and other recent storms, as well as future climate projections, to develop feasible, cost-effective strategies to reduce and manage extreme weather vulnerabilities amid the uncertainties of a changing climate. These strategies include designing a protective seawall for a tunnel ventilation building so that it can be adapted to future sea level rise and storm surge conditions as needed, as well as relocating flood-vulnerable electrical and mechanical drawbridge equipment. The transportation agencies chose 10 regionally significant facilities—ranging from roads to bridges, rail, and ports—for engineering-informed adaptation assessments. They used results from the storm damage assessments and the engineering-based adaptation assessments to inform a multimodal transportation vulnerability and risk assessment for the region, as well as adaptation strategies for three critical subareas. The study provides lessons learned in addressing climate change risks across the entire transportation life cycle—from planning to operations and emergency response.

The agencies expected the project to be complete by the end of 2016.

information on this guide can be found at www.ops.fhwa.dot.gov/publications/fhwahop15026.

The consideration of climate change is also included in guidance for FHWA's emergency relief program. The May 2013 update to the program's manual notes that "FHWA supports planning, designing, and constructing highways to adapt to current and future climate change and extreme weather events" when rebuilding a damaged facility with emergency relief funds. If an agency is considering moving a damaged facility, the new location should be evaluated to determine susceptibility to damage from climate change. The manual for FHWA's emergency relief program is available at www.fhwa.dot.gov/reports/erm/er.pdf.

Sharing Adaptation Strategies Across the World

In addition to learning from State and local partners, FHWA is exchanging information with the international community on how DOTs are adapting transportation infrastructure to the impacts of climate change.

For example, FHWA conducted a virtual review to study how transportation agencies worldwide are working to adapt highway infrastructure. The review team spoke with transportation agencies in eight countries, including Australia, New Zealand, the Republic of Korea, and the United Kingdom, among others, on all aspects of the delivery process for transportation projects, including policy development, planning, design, construction, operations, and maintenance. The findings from the review can be found in *International Practices on Climate Adaptation in Transportation—Findings from a Virtual Review* (FHWA-HEP-15-012).

In September 2015, FHWA cosponsored the Transportation Research Board's first International Conference on Transportation System Resilience to Climate Change and Extreme Weather Events. The conference and live webcast convened more than 500 experts from across the world to explore state-of-the-art research and emerging practices and policies on adapting surface transportation networks to the potential impacts of climate change and extreme weather. The Transportation Research Board provided a synopsis of the event in its *E-Circular 204: Surface Transportation System Resilience to Climate Change and Extreme Weather Events—First International Conference*.

Next Steps

FHWA will continue to highlight best practices and develop guidance for incorporating climate risks into system planning, project design, and operations and maintenance.

In addition, the agency is expanding its existing portfolio of case studies highlighting adaptation and resilience activities in the transportation sector. These include information on the recently completed pilot projects as well as research projects conducted by FHWA and other transportation agencies.

Also, FHWA officials are looking across sectors to better coordinate efforts to address climate change resilience, as well as resilience to other potential risks. For example, the FHWA Office of Policy and Governmental Affairs is leading a project to look at the resilience of the National Highway System with respect to risks such as earthquakes and terrorism. The project will be developing metrics and indicators for assessing the resilience of the system and exploring how disruptions to other transportation modes would affect its operation. The project was expected to be completed by the end of 2016.

In addition, a new project called Green Infrastructure Techniques for Coastal Highway Resilience seeks to improve the resilience of coastal roads, bridges, and highways through implementation of green infrastructure and ecosystem-based approaches. The project will investigate techniques that could be implemented as part of transportation planning, construction, and maintenance to preserve and improve natural infrastructure functions, thereby increasing the resilience of highways to the effects of storm surges and sea level rise. Coastal green infrastructure includes dunes, wetlands, living shorelines, oyster reefs, beaches, and artificial reefs. These features can protect coastal transportation infrastructure from the brunt of storm surges and open water waves. Some can adapt to sea level rise by accumulating sediment or migrating inland.

Using FHWA emergency relief funds, the Colorado DOT contracted with FHWA's Central Federal Lands Highway Division to rebuild this stretch of U.S. 36 between Lyons and Estes Park that was damaged by flooding in 2013. Shifting the road a few feet farther from the river and using grouted riprap and native vegetation to stabilize the riverbank will help make the road more resilient to future floods. *Photo: Colorado DOT.*

"Although scientists cannot predict precisely how the climate will change across the country, most agree that it will continue to change and cause a range of impacts," says Emily Biondi, acting director, FHWA's Office of Natural Environment. "Anticipating and preparing for climate change is essential to maximizing service while minimizing long-term costs. FHWA will continue to work with our partners and stakeholders to ensure that the United States has a resilient transportation system now and in the future."

Heather Holsinger is an environmental specialist with the Sustainable Transport and Climate Change Team within FHWA's Office of Planning, Environment & Realty, where she focuses on policy development and analysis in the areas of climate change adaptation, sustainability, and alternative fuel vehicles. She holds master's degrees from Duke University in resource economics and public policy and a bachelor's degree from the University of Virginia in economics and environmental science.

For more information, see www.fhwa.dot.gov/environment/climate_change/adaptation. Or contact Heather Holsinger at 202-366-6263 or heather.holsinger@dot.gov.

Engaging officials and the public is essential to successfully implementing innovations on tribal, county, city, and other municipal roads.

Championing Safety on Local Roads

by Rosemarie Anderson, Pamela M. Beer, and Danena Gaines

Improving safety and operations on local roads is no easy task. Local roads are defined as those owned and operated by local jurisdictions (county, township, or other municipality) and not restricted by functional classification. The sheer number of these roads and their owners and operators presents a challenge. Approximately 75 percent of the Nation's roadways are local roads, and they are owned and operated by more than 30,000 agencies, including county, city, town, tribal, and other owners. Further complicating the matter is that these agencies have significant diversity in resources, including traffic expertise and funding.

Transportation agencies implement safety improvements through coordination and collaboration with a variety of traffic safety professionals and stakeholders. Local safety practitioners serve an important role in choosing new and innovative approaches to make roads safer. However, transportation professionals and safety practitioners depend on local officials who approve budgets and make decisions on the use of resources. Because of this essential link, engaging local officials in adopting innovations in transportation can greatly assist safety practitioners in improving roadway safety for the traveling public.

Increasingly diverse innovations in traffic safety (such as roundabouts, enhanced delineation and high friction surface treatments for horizontal curves, road diets, and signing inventories) also make it more important than ever for traffic safety practitioners to work with local public officials. Practitioners can help officials understand the importance of these improvements to the safety of their communities and become champions for their use.

Transportation professionals also need to inform public officials

(Above) Innovations like this roundabout, which accommodates motor vehicles, pedestrians, and bicyclists, can have many safety and operational benefits but require buy-in from local officials and the public. *Photo: Caleb Van Horn, GHD.*

that the methods to identify and prioritize improvements have advanced. For example, the systemic approach to safety improvement process identifies potential locations for improvements based on risk rather than simply locations where crashes have occurred.

Local transportation and public works professionals should always engage appropriate decisionmakers, including public officials, on innovative practices to gain the necessary buy-in and resources needed to implement improvements.

Engaging and Informing Local Officials

Local officials must address many public concerns, including transportation, public safety, economic development, and city or county services, often with limited budgets and revenue. They represent cities, counties, consolidated governments, and tribal lands. Local public officials are the ones who make decisions about how Federal, State, and local transportation funds are spent, as well as how resources (staff, equipment, materials) are used. These decisionmakers may include city councilpersons, county commissioners, mayors, county or city managers, public works directors, city or county engineers, and law enforcement officials.

Proactively engaging local officials in the process of adopting new traffic safety innovations can keep them informed and supportive, ease the implementation process, and, most important, improve local road safety. Safety professionals should inform local officials of the most pressing traffic safety challenges in their jurisdictions and arm them with the knowledge of potential solutions so they can act as champions for safety improvements in their communities. Henderson, NV, for example, has found a champion in Councilwoman Debra March.

"It's important to involve elected officials in traffic safety issues as we meet regularly with our engaged constituents," says Councilwoman March. "These meetings provide an opportunity to communicate the initiatives and programs our traffic engineers and police officers are implementing to improve traffic safety. Delivering a compelling story, backed with empirical data, resonates with our constituents, gains their support, and improves safety for everyone in our community."

Greater collaboration and coordination with safety practitioners benefits public officials because they better understand the technical approaches available to address specific issues relevant to their constituents.

"The biggest challenge is education," says James Nall, traffic division director with the Public Works Department in Mesa County, CO. "Anyone who has a driver's license often believes [he or she has] expertise in safety, but there is a great deal of science behind it. That is why we need to educate our elected officials."

Preparation Is Key

To begin, practitioners should identify key local officials to determine their interest in traffic safety issues and their information needs related to road safety. Also vital is gathering pertinent data on the traffic safety issues within the jurisdiction (such as crash, roadway, trauma, citation, adjudication data) and identifying proven innovations to address the issues.

The information that practitioners use to make their case will vary depending on the traffic safety challenge, the innovation being discussed, and the local official's position (for example, elected or appointed) and established interest. Some examples of sources of information include public needs and preferences gathered from public involvement activities, expected demographic and socioeconomic changes, and information gathered from road safety audits. It is also important to identify the nature of the safety problems, where they are occurring, and the risks associated with them, as well as crash data, causes, and citizen concerns relevant to the issue. In addition, prepare information on potential safety strategies, countermeasures, and funding options for implementation.

After collecting and compiling key information, practitioners often will make initial contact through local official's staff. Practitioners should be prepared to present the facts—data, proposed solutions, and costs with an eye for solutions scaled to a level that officials are able to address. For example, instead of proposing enhanced delineation and friction treatments for every horizontal curve in a county, propose implementing the improvements on only the higher risk curves initially, within a reasonable budget for the agency. Most important, practitioners should be prepared to educate officials and their staff members on proven, effective, low-cost solutions. Preparing a one-page summary with main points to leave behind might be helpful, as officials can refer to it in the future or use it to educate other decisionmakers.

Engaging Federal and State agency safety experts can assist local practitioners in their outreach

Councilwoman Debra March of Henderson, NV, is shown here with State Senator Mark Manendo at Nevada's Traffic Safety Summit in May 2016. *Photo: Nevada Department of Transportation.*

Michigan LTAP Workshop for Elected Officials

The Michigan Local Technical Assistance Program (LTAP) hosted a workshop on "What Elected Officials Need to Know About Traffic Safety" to educate local officials on technical issues and provide an informed basis for decisions.

The participants were exposed to real-world examples of commonly misunderstood traffic safety concepts such as the safety benefits of roundabouts. The workshop content included Michigan crash data, factors influencing crashes on Michigan roadways, and other technical information and resources.

A followup study on the effectiveness of the workshop showed a 15:1 ratio of secondary transfer of information after training elected officials. The data were gathered through surveys of attendees within 12 months after the training event. Individuals self-identified the number of people they transferred material to and how they transferred the materials.

to local officials. In addition, Federal and State agencies often can provide training and technical assistance needed for the identification and implementation of proposed safety improvements.

Strategies to Engage Local Officials

Because local officials receive many requests for funding and demands for their time and attention, several strategies can help make every minute with them count.

Understand the issue/innovation by researching the facts, benefits to the local community or State, and potential costs. Supplement facts and figures with stories of crashes in the community and explain how the innovation may reduce or prevent such crashes. Make the issue personal to the local official and the community.

Steve Latoski, public works director for Mohave County, AZ, suggests an effective formula for making this personal connection to traffic safety issues. "Emphasize results, especially lives and dollars saved," says Latoski.

Acknowledge the arguments against the innovation and, to the extent possible, identify information that overcomes the argument. Emphasize results seen in similar cases, gather information on proven countermeasures, and synthesize common results to make your case.

"Any time you're [asking someone to consider] spending money it could be a tough sell," said the late David Brand, who served as county engineer in Madison County, OH. "There are going to be questions, but part of that sell is to have those answers and to present the information in a way that the elected officials can then get their arms around it and also return support for it."

Identify partners (organizations and individuals) who can support the cause. Share the results of public outreach. Get involved in any local, regional, or statewide efforts on traffic safety (such as strategic highway safety plans) to build connections that can be beneficial to safety improvement programs. In many instances, local officials are already involved in efforts to develop regional and local transportation efforts. Working toward safety goals together can help to build and strengthen essential relationships.

Determine an approach to communicate with local officials. Be brief, concise, and clear on what is needed, use nontechnical (common) language to explain concepts, and provide graphics and other visual aids when possible. The approach should be similar to communicating with the public about traffic safety.

Joseph Marek, traffic safety program manager in Clackamas County, OR, has worked hand in hand with local officials. "You don't need tons of technical jargon to talk about things that are really common sense, and when you talk to citizens they get that . . . . They can't rattle off equations, but they know when that [road] sign shouldn't be there," he says.

Identify opportunities to engage local officials. Use town hall meetings and one-on-one meetings or briefings to present data, proposed solutions, and costs. Be concise when presenting information. Public comment during regular city council or county commissioners meetings are also potential opportunities for practitioners to make presentations on innovative practices.

Metropolitan planning organizations have technical advisory committees made up primarily of representatives from local jurisdictions, departments of transportation, transit agencies, and the Federal Highway Administration. The technical advisory committees usually meet monthly or quarterly to

Brett Fusco, Delaware Valley Regional Planning Commission

The Delaware Valley Regional Planning Commission held a public visioning workshop as part of its *Connections 2045* long-range plan update. At the workshop, these participants discussed their values, concerns, and future forces, and identified their vision for transportation in the region.

Greg Parker, Johnson County, IA

This county engineer (far right, pointing) explains design features of a partially constructed bridge during a road tour for elected officials in Iowa.

provide input and guidance into all transportation planning activities. These committee meetings may be another opportunity to engage local officials on traffic safety issues and present information on proposed improvements and countermeasures.

Provide information on available resources. Information on proven effectiveness along with the cost and examples of best practices can go a long way to promote an innovation. General background information on local and rural road safety needs and reports on projects and countermeasures are available on FHWA's Local and Rural Road Safety Program Web site at http://safety.fhwa.dot.gov/local_rural.

Follow up after your meeting with local officials. Send a thank you and offer to provide additional information or presentations if needed. Invite the local official and his or her staff to attend upcoming open houses and road safety events. Offer public knowledge of the official's support, such as a speaking role at a ribbon-cutting ceremony or safety meetings.

A Downtown Revival in Grand Junction, CO

The city of Grand Junction, CO, has been a leader in roadway innovations since 1962 when it proposed the first "road diet" for Main Street. A more recent showcase of how the city embraces innovation is the redesign of its downtown.

"Grand Junction has always supported innovations," says Trent Prall, engineering manager for the city. "We did road diets before they were even called road diets, have converted numerous intersections to roundabouts, and, in partnership with the Colorado Department of Transportation, had the first [diverging] diamond interchange in the State."

The city's downtown is virtually the "heart" of the community. However, residents had begun to go to areas outside the city for shopping and entertainment instead of the downtown area. To develop a plan to make the downtown area an appealing place for residents to visit, the Public Works, Utilities, & Planning Department reached out to stakeholders including business owners, residents, visitors, road users, commercial vehicle operators, pedestrians, bicyclists, event organizers, and other special interest groups. The plan included implementing a road diet and other improvements to encourage walking and biking along with accommodations for vehicles.

Prall notes the importance of the Grand Junction Public Works, Utilities, & Planning Department articulating its goals. "We had a comprehensive plan for the city, which called for complete streets, pedestrian and bicycle improvements, and

Resources to Improve Communication With Elected Officials

FHWA has developed a brochure, *Communicating About Local Road Safety with Elected Officials* (FHWA-SA-16-019), and a video of the same title, with tips for communicating about road safety with local elected officials.

To download the brochure, visit http://safety.fhwa.dot.gov/local_rural/training/fhwasa16019/fhwasa16019.pdf.

The video is available at www.youtube.com/watch?v=vQd8feJyXH0&feature=youtu.be.

City of Grand Junction

Grand Junction, CO, revitalized its downtown after innovations to increase public use through a road diet. The improvements encourage walking and biking, and parking on side streets provides easy access to the businesses in the area.

other safety improvements," he says. "It was also helpful that many local councilmembers were also active in the Colorado Municipal League, which made members aware of new improvements in roadway design."

For example, most members of the city council understood the safety benefits of road diets, but wanted to make sure that the reduction of traffic lanes from four to three could handle future traffic growth. "For road diets, we are very specific about how we address capacity and balance the needs of automobiles, trucks, transit, and pedestrians [and] bicyclists," Prall says.

As the public works department proposed additional improvements, the agency made sure to understand the concerns and arguments against the innovations in order to address them effectively. "We did a lot of upfront work to get to know our elected officials, so we knew their concerns and could identify who was pro-bicycle and who was more interested in capacity, and address their concerns," says Prall. "We also tried very hard to put ourselves in the shoes of each stakeholder and anticipate his or her needs."

The department also did a lot of preparation to have all the facts and to demonstrate to officials how the innovation worked in comparable cities. "We also met one on one with all of our local officials, adjacent property owners [and] tenants, and other key stakeholders," says Prall. "We discussed the change in detail. This is a much better strategy than presenting the information in a large meeting or hearing."

The redesign of downtown has led to a thriving area with shops, restaurants, hotels, and other services. Rather than reducing capacity, the improvements have helped the downtown compete with other, newer shopping areas by providing an attractive, walkable environment for shopping and dining.

In addition, the Public Works, Utilities, & Planning Department has not limited innovations to just downtown. The valley now has 18 roundabouts, a testament to the effectiveness of engaging local officials in adopting innovations.

Prall provides this advice on gaining support for roadway innovations from local officials and stakeholders: "If you bring them in early, they are your partners; bring them in late, and they are your judge[s]."

Working Together

When local safety practitioners and officials work together to implement traffic safety innovations, everyone in the community benefits. Safety practitioners can do their part by thoroughly researching the facts about their transportation challenges, identifying the best potential solutions, and making the case to local officials for implementing proposed improvements. Local officials can examine the information provided by practitioners and consider the proposed alternatives, work with transportation agencies to develop a proposed plan of action, and champion the cause for funding.

Rosemarie Anderson is the local and rural roads manager with the FHWA Office of Safety. She has more than 30 years of experience in transportation planning and engineering. She holds an M.S. in transportation and an M.S. in financial planning from the New Jersey Institute of Technology.

Pamela M. Beer is a senior associate with Cambridge Systematics, Inc. She has nearly 30 years of experience in the areas of highway safety, strategic planning and analysis, communications and community outreach, public awareness, media relations, and transportation safety planning. Beer has worked with FHWA to develop marketing plans and materials for many programs, including *Improving Safety on Rural Local and Tribal Roads: Safety Toolkit* (FHWA-SA-14-072) and the National Center for Rural Road Safety. She has a B.F.A. from The University of Utah.

Danena Gaines, Ph.D., is a senior associate with Cambridge Systematics with 10 years of experience in transportation safety planning, data collection and analysis, traffic safety research, and local and rural road safety culture. Gaines has worked with FHWA to document local road safety practices. She holds an M.S. and a Ph.D. in civil engineering, with a concentration in transportation, from Georgia Institute of Technology.

For more information, see http://safety.fhwa.dot.gov/local_rural or contact Rosemarie Anderson at 202-366-5007 or rosemarie.anderson@dot.gov.

New Guide on Rumble Strips

Want more informed decisions, targeted safety investments, and fewer fatalities and serious injuries from roadway departures? Check out FHWA's new ***Decision Support Guide for the Installation of Shoulder and Center Line Rumble Strips on Non-Freeways.***

The guide describes methods for assessing potential crash reductions, determining benefit/cost ratios, and developing performance metrics for safety. And more:

- **Selecting sites for installations**
- **Determining effectiveness**
- **Current systemic policies**
- **Successful case studies**
- **Decision support framework**
- **Special considerations**

Free download at **http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips**
For more information, contact cathy.satterfield@dot.gov.

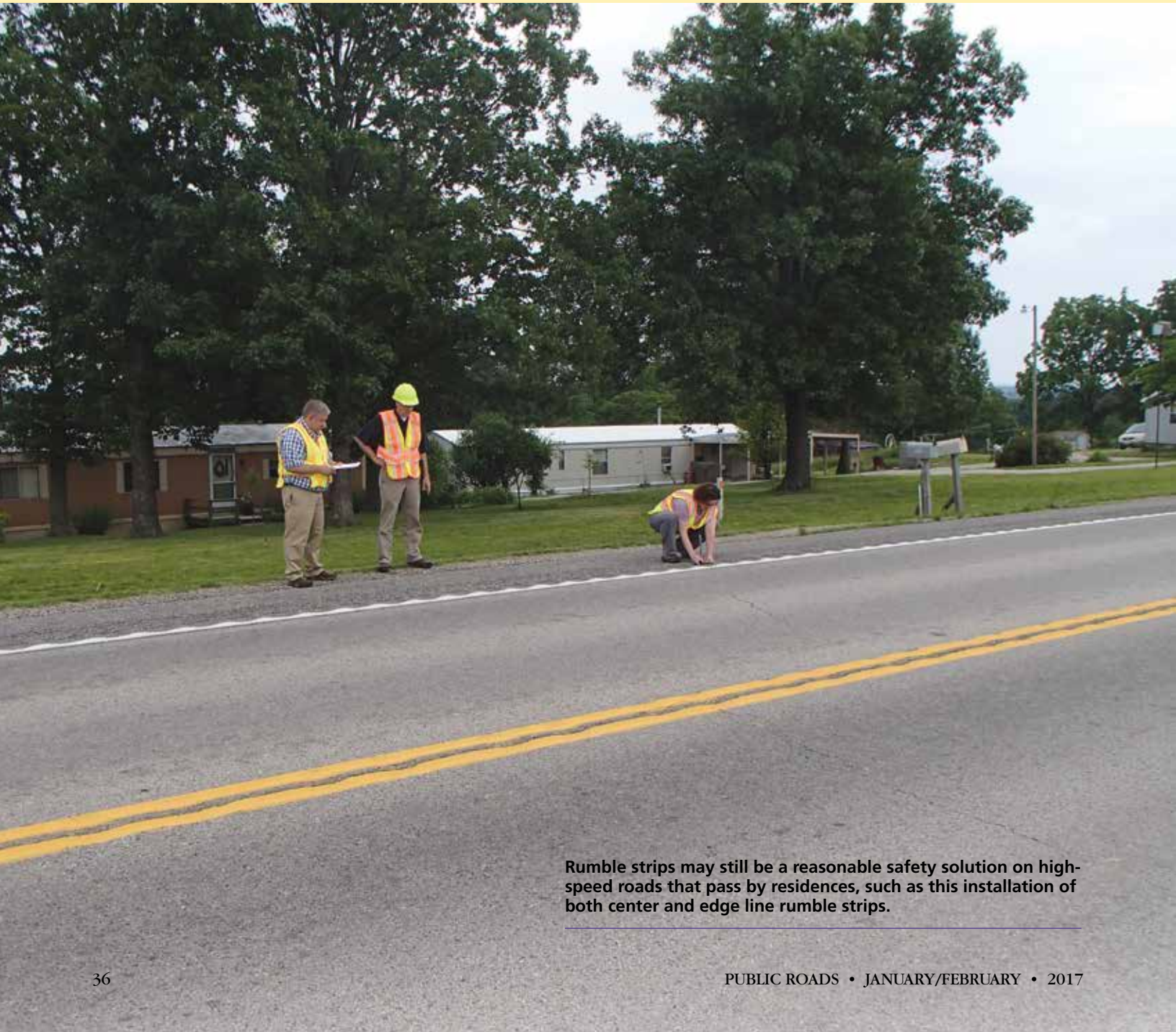
U.S. Department of Transportation
Federal Highway Administration

http://safety.fhwa.dot.gov/roadway_dept

Did You Hear That?

by Lisa Kinner Bedsole, Ken E. Johnson, and Cathy Satterfield

Mumble strips show promise for fewer roadway departures with reduced road noise near residential and environmentally sensitive areas.



Rumble strips may still be a reasonable safety solution on high-speed roads that pass by residences, such as this installation of both center and edge line rumble strips.

In 2014, more than half of traffic fatalities in the United States resulted from roadway departure crashes. The Federal Highway Administration defines roadway departure crashes as crashes that occur after a vehicle crosses an edge line, a center line, or otherwise leaves the traveled way. Sometimes the cause of these crashes is fatigued or distracted drivers drifting over the center line or the edge line of their lane. In such cases, one of the most effective safety countermeasures to reduce run-off-the-road and head-on crashes is the rumble strip.

A series of milled pavement corrugations or raised media affixed to the road surface (such as raised pavement markers) near the edge lines or center lines, rumble strips cause a combination of vibration and a staccato sound within the vehicle when they are struck. Together, the vibration and sound alert a driver that the vehicle is drifting out of the travel lane.

Since the 1990s, many studies of rumble strips' safety performance have validated the safety benefits of this countermeasure when the design is the traditional milled cylinder shape and spacing—7 × 12 × 0.5 inches (18 × 30 × 1 centimeters) spaced 12 inches (30 centimeters) center-to-center—typically used in the United States. For example, a study under the National Cooperative Highway Research Program (NCHRP) found that, for head-on and opposite direction sideswipe collisions, milled center line rumble strips provide reductions in injury crashes of 45 percent on rural two-lane roads and 64 percent on urban two-lane roads.

Although the safety benefits are impressive, installations of rumble strips sometimes create complications. For example, rumble strips located on the shoulder and edge line can be difficult for bicyclists to traverse without slowing their speed significantly. In addition, the most common concern currently—and the one that sometimes results in the costly removal of rumble strips—is related to external noise when vehicles strike the rumble strips. Although this type of rumble strip is not in the driving lane, drivers may incidentally hit the rumble strip when making a passing maneuver or taking a curve too widely. Unfortunately, the unexpected and loud noise generated when a vehicle hits a rumble strip can be disruptive to those in the surrounding area. Transportation agencies often choose not to install rumble strips in the vicinity of residences or other noise-sensitive receptors because of these concerns, restricting the potential safety benefit of the countermeasure.

Many agencies have tried reducing dimensions of the milled cylinder shape to address some of the issues, but an entirely new design of rumble strips that uses an oscillating sine wave pattern has shown some potential to significantly reduce noise outside of the vehicle. Can researchers find an appropriate depth, width, and spacing of the sinusoidal pattern—dubbed the "mumble strip"—that will provide enough noise and vibration inside the vehicle to alert drivers that they are drifting from their lane? Read on to find out.

Research Into Quieter Pavements

California experienced an average of 1,370 fatalities from roadway departures annually from 2010 through 2014. To combat these types of fatalities, the California Department of Transportation (Caltrans) installs milled center line and shoulder or edge line rumble strips, with a recommendation that the shoulder should be a minimum of 5 feet (1.5 meters) wide to facilitate use by bicyclists. The agency's policy is to consider rumble strips in all resurfacing projects, and it encourages designers to use engineering judgment and consider the risks of run-off-road and head-on crashes when determining whether rumble strips are advisable.

As a result of its extensive experience dealing with the acoustic impacts of highway noise, Caltrans has a long-standing interest in traffic noise abatement. In the mid-2000s, for example, Caltrans conducted a study to compare noise measurements on various European pavements to similar data obtained for pavements in California and Arizona. The relationships that Caltrans researchers developed with the European researchers would become a key factor a few years later as they began to address noise issues related to rumble strips.

In 2005, the United Kingdom's Department for Transport published an advisory based on research for a "quieter alternative to conventional rumble strips." This research sought to refine the design of *transverse* rumble strips that are placed across the travel lane for a short distance to warn all motorists of an upcoming condition rather than narrow, continuous rumble strips at the edges of the travel lane to warn drivers who are moving outside the travel lane. However, the recommended sinusoidal design and profile would prove to be a starting point for later research on center and edge line rumble strips.

In 2007, Danish researchers published a seminal study that tested rumble strips designed specifically to generate low noise levels. The study tested five types of milled rumble strips, two depths of the sinusoidal design and three depths of cylinder shape, all more shallow than the depth that has proven to yield crash reductions in the United States. The Danish researchers calculated that, at distances exceeding approximately 82 feet (25 meters) from the road, passenger cars riding on sinusoidal indentations led to an increase of only 0.5–1 decibel in the maximum pass-by noise level compared to the noise of the same vehicles passing by on the pavement with no rumble strip. The cylindrical indentations gave a maximum increase of 2–7 decibels.

Note that a difference of 5 decibels is considered readily noticeable. NCHRP *Report 641: Guidance for the Design and Application of Shoulder and Centerline Rumble Strips* recommends that rumble strips create an increase in interior noise level of 6–15 decibels to be effective. The Danish study did not measure noise inside the vehicle, but multiple later studies have done so and found that the increase in interior noise varies based on vehicle type, vehicle speed, and rumble strip design.

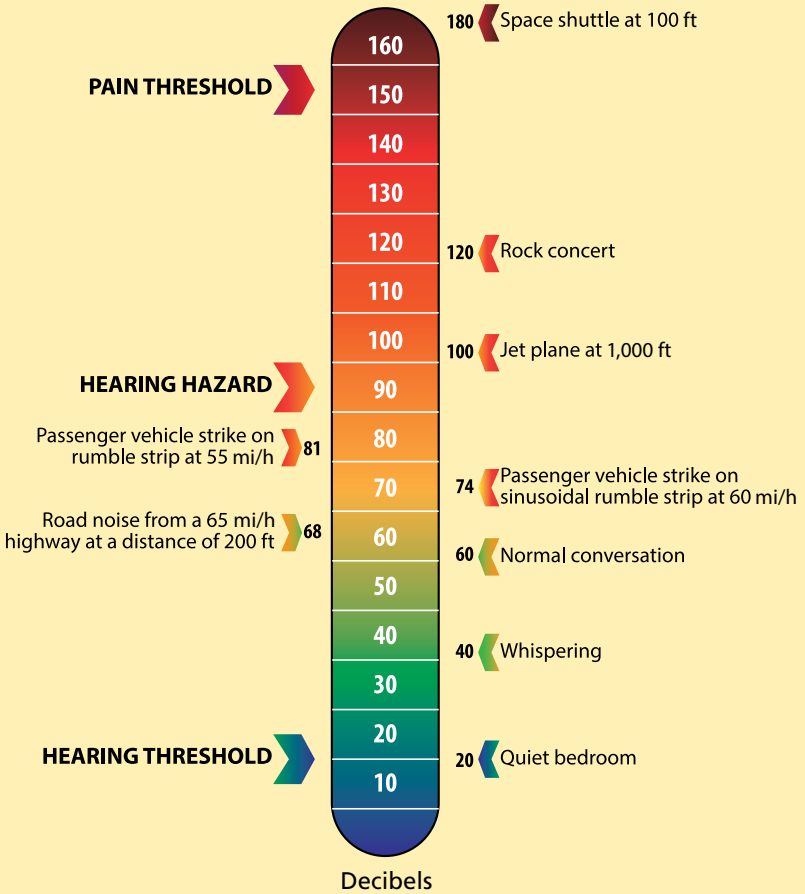
The British and Danish studies came to the attention of staff at Caltrans' Division of Environmental Analysis as the division was receiving increasing inquiries from its districts about how to deal with noise complaints related to rumble strip strikes. A number of citizens and Caltrans staff also expressed concerns about noise pollution

The Mechanics of Sound

Sound has many frequencies and is measured in decibels (dB). There are many weighting scales to hone in on various frequencies, the most common being the A-weighted scale (designated dBA) that focuses on frequencies within the range of human hearing. Because sound is measured on a logarithmic scale, when two sources of sound, each measuring 70 dBA, are added together, the resulting sound level is not 140 dBA but 73 dBA. As a result of this logarithmic scale, an increase of 10 dBA is essentially a doubling of perceived sound. Conversely, a decrease of 10 dBA is a halving of sound.

For example, a normal conversation at a range of about 3 feet (0.9 meter) measures between 60 and 65 dBA, and highway traffic noise at a distance of about 50 feet (15 meters) from the road typically ranges from 70 to 80 dBA. Most people would consider an increase (or decrease) of 1 to 3 dBA to be barely noticeable. It takes about a 5 dBA change in sound to be definitely or readily noticeable.

Noise Thermometer



Source: FHWA.

It is also important to note that a difference exists in perception of intermittent noises (such as the occasional rumble strip impact by a vehicle drifting from the travel lane) and more consistent background noise (for example, the hum of a generator). People are more likely to find intermittent, loud noises more noticeable, and often more bothersome, than steady noise at a slightly elevated decibel level.

In terms of pavement noise, one of the key parameters affecting road noise is texture. Road noise increases both with positive textures, which stick up from the roadway (such as raised pavement markers), as well as with transverse textures, which are perpendicular to the direction of traffic. Milled rumble strips are an example of a transverse texture.

resulting from rumble strip strikes in environmentally sensitive areas, especially in parks, nature reserves, and tribal lands. It was clear that district engineers needed a noise-reducing design alternative that would maintain safety benefits.

"The public is always concerned about the noise levels generated by transportation infrastructure," says Bruce Rymer, a senior engineer and acoustician with the Caltrans Division of Environmental Analysis. "With a little more thoughtful design, the noise levels can be turned down on elements like pavement, bridge decks, bridge joints, and rumble strips."

In response, Caltrans contracted a motor vehicle noise and vibration engineer to begin studying whether existing rumble strip patterns could be improved to reduce noise. Caltrans has many miles of sound walls, but the most efficient noise control strategy is to turn down the volume at the noise source rather than disrupt the sound transmission path with a barrier or install some form of noise insulation at the receptor. Could researchers find a design that would lower noise outside the vehicle while maintaining or increasing it inside the vehicle?

The Mumble Strip

In 2009, researchers from the Danish Road Directorate (who had participated in the 2007 study) were on sabbatical in California and observed the research. It was a member of the Danish team who first coined the term "mumble strip" as a joke, but the U.S. researchers, amused by it, quickly picked up the term. Caltrans' initial investigations and testing concluded that sinusoidal mumble strips could achieve the design goals of lowering exterior noise levels in the human hearing range and still provide sufficient driver warning. As expected, interior noise and vibration levels did vary depending on the test vehicle used.

Earlier quiet pavement research at Caltrans had found that some pavement surface textures are noisier than others and that raised (positive) texture is louder than recessed (negative) texture. Caltrans' 2009 work resulted in a recommendation for an internal design concept that built on previous research for both quieter pavements and the

Raised pavement markers like these are one method for creating an audible vibration that can alert drivers when they are leaving a travel lane.

Danish experiments with the sinusoidal rumble strip shape. Caltrans' design goal was a sinusoidal pattern that minimizes the "harsh" impulse noise from existing rumble strip designs but still increases interior noise levels by 6 dB or more. The optimal wavelength or period for the sinusoid shape Caltrans was looking for would take into account U.S. standards for vehicle speed and tire width and diameter. The internal memo that resulted from the 2009 Caltrans research recommended an optimal period and depth regardless of speed.

Embracing the recommendation, Caltrans District 1 engineers began working to identify a potential test site for installation and to refine the approach to applying the concept in a test scenario. At the time, they were interested primarily in using the sinusoidal shape on edge lines and shoulders rather than on center lines. In July 2012, the district installed the mumble strips on a 7-mile (11-kilometer) road segment to demonstrate the design, followed by a study in September 2012.

After analyzing the data from the study, the engineers determined that the conceptual sinusoidal mumble strip pattern does lower roadside noise levels while maintaining interior cabin noise and vibration levels adequate to alert the driver.

Caltrans is pursuing a patent regarding its optimal sinusoidal rumble strip. Once the patent has been granted, the agency will look at how it can adjust its policy and approach toward applying rumble strips, including developing a set of recommendations on when and where its mumble strip design should or should not be applied.

"It's far more cost effective to lower the noise generated at the source than to attempt to block it or provide noise insulation at the receiver," says Rymer. "We need to think of our roadway design elements like washing machines and dishwashers—design them to be quiet."

Minnesota Builds on Caltrans' Research

As is the case for many States, fatalities and serious injuries as a result of roadway departure crashes are

This side view with a long straightedge laid on top of the pavement shows the sinusoidal shape of California's mumble strip design. *Photo: Caltrans, Caltrans 2014 Excellence in Transportation Award Winners, Transportation Innovations Category, "Mumble Strip Installation and Evaluation."*

overrepresented in Minnesota. For example, of the 1,922 highway fatalities that the State experienced in 2010–2014, 52 percent were attributed to vehicles either running off the road or crossing the center line into oncoming traffic.

To combat this safety issue aggressively, in 2011 the Minnesota Department of Transportation (MnDOT) revised its policy on rumble strips. The revisions mandate that on rural trunk highways where the posted speed limit is 55 miles per hour (88 kilometers per hour) or greater, and the paved shoulder width is 4 feet (1.2 meters) or greater, shoulder rumble strips are to be placed on all rural highway projects that involve constructing, reconstructing, or overlaying shoulders. Center line rumble strips are subject to the same policy when constructing, reconstructing, or overlaying pavement, and the policy applies to both multilane undivided and two-lane undivided highways.

However, the resulting widespread application of rumble strips garnered its share of noise complaints from residents in certain areas. These complaints fueled MnDOT's interest in California's study of the sinusoidal shape.

In 2015, MnDOT initiated the *Sinusoidal Rumble Strip Design Optimization Study*, which concluded in mid-2016. The final report is available at www.dot.state.mn.us/research/TS/2016/201623.pdf. This study built upon earlier work sponsored by the Minnesota Local Road Research Board, which compared three sinusoidal designs on the shoulders of county roads in Polk County, MN.

The goal of the 2015 MnDOT study was to determine an optimal sinusoidal design or designs that would lower nuisance noise levels, provide adequate warning to drivers who inadvertently are leaving a lane, and be safe for bicyclists and motorcyclists to traverse.

"In Minnesota, we've had a one-size-fits-all rumble strip," says Will Stein, safety and design engineer with FHWA's Minnesota Division.

"So the idea was to give designers more tools. Much like design should be tailored to the highway's context, safety measures like rumble strips can be better fitted to their surroundings."

Phase 1: Broad Evaluation of Designs

MnDOT conducted the first phase of the study at its MnROAD test track near Albertville, MN. The purpose of phase 1 was twofold: (1) to subjectively evaluate a broad array of sinusoidal rumble strip designs and narrow them down to the most promising for more detailed field testing and noise measurement; and (2) to obtain feedback from motorcyclists and bicyclists on various designs within a safe, closed-track environment.

MnDOT researchers milled various sinusoidal configurations into the test track. They also milled MnDOT's standard shape, which is the cylindrical design and dimensions proven in the NCHRP *Report 641* to reduce crashes significantly. All of the sinusoidal rumble strips were milled to the same depth of 0.0625 inch (0.16 centimeter) at the high point and 0.375 inch (0.95 centimeter) at the low point. The differences among the designs included:

- Wavelength variations at 12, 14, and 16 inches (30, 36, and 41 centimeters).
- Widths of 14 inches (36 centimeters) for single-row rumble strips, and widths of 8 inches (20 centimeters) for double-row rumble strips. Double-row rumble strips were separated by 4 inches (10 centimeters) of pavement.
- Rumble strips with tapered edges versus straight vertical edges—to evaluate any difference for bicyclists and motorcyclists.

The MnROAD research team tested the array of rumble strip designs, as did the project's technical advisory panel. The evaluation was subjective, but the broad consensus was that the 14-inch (36-centimeter) wavelength provided the best in-vehicle noise and vibration level. All wavelengths produced considerably less external noise compared to standard rumble strips.

Motorcyclists and bicyclists also evaluated the designs for traversability. Riders crossed over the rumbles to simulate passing maneuvers and rode along the rumbles to simulate tangential hits. Motorcyclists expressed clear preference for the single-row design, noting that it was more comfortable to traverse and provided more stability than the double-row configuration.

In addition, bicyclists noted that they preferred the sinusoidal shape because it is less jarring to ride over than the standard design. Neither group had a strong preference for the tapered versus vertical edges.

From this subjective feedback, which identified the 14-inch (36-centimeter) wavelength as the most promising sinusoidal shape, researchers selected four configurations for more detailed study on Minnesota State Highway 18 (MN 18).

Phase 2: Detailed Field Testing

For the MN 18 field testing, researchers conducted an additional subjective evaluation in combination with measurement of noise levels internally and externally using a noise meter. To measure noise levels within vehicles, they used a passenger car, a pickup truck, and a MnDOT tandem dump truck. They also measured noise levels externally at distances of 50 and 75 feet (15 and 23 meters) from the highway.

The study concluded that external noise was much lower for all four sinusoidal designs compared to the standard rumble strip. Internal noise for the passenger vehicle was strong for all four sinusoidal designs. The range for internal noise for the pickup did not vary greatly, but the 0.5-inch (1.3-centimeter) depth did provide a more audible warning. Noise levels within the dump truck, however, were difficult to detect above the engine and other noise from the truck itself. Consequently, areas that experience a high number of roadway departures for trucks may not be ideal candidates for installing sinusoidal rumble strips.

The study determined that the optimal sinusoidal design for asphalt pavements is the single-row 14-inch (36-centimeter) rumble strip that is 0.5 inch (1.3 centimeters) at its deepest point. For concrete pavements, Minnesota is considering a double row of 6-inch (15-centimeter) rumble strips to avoid milling through the joints. These will also be 0.5 inch (1.3 centimeters) deep. Both designs will use a 14-inch (36-centimeter) wavelength.

One of the additional benefits of MnDOT's modified sinusoidal design is the increased durability of pavement marking. Theoretically, placing the pavement marking within the sinusoidal rumble will provide a greater lifespan for the pavement marking because the entire marking will be below the surface of the pavement. MnDOT found that a surface-applied latex will last 1 year, while recessed latex will last 3–4 years. The estimated longevity for an epoxy marking is 3–4 years; for recessed epoxy, the agency expects a 6–7 year lifespan.

Moving forward, MnDOT will revise its rumble strip policy to add a sinusoidal design option for noise-sensitive locations. However, Minnesota will not stop using traditional rumble strips. The current rumble design will likely remain the default, with the sinusoidal mumble design as an option when needed. District traffic engineers will make the decisions regarding applying the most aggressive safety design that is appropriate for the conditions.

Future Directions

Ongoing research into reengineering traditional rumble strips is motivated by the understanding that road designers need new tools that fit within the context of different areas and roadways so that they can take locational needs into consideration. To date, engineers from both Caltrans and MnDOT have described the research as "very promising."

Although these studies into alternative designs have established interesting and informative results, researchers have examined only a few shapes and variations in depth in the United States. Experience with the standard rumble strip design indicates statistically significant crash reductions, but it will take approximately 5 years of study after installation of several hundred miles of the mumble strips (or any other shapes) before agencies have enough crash data to determine the actual safety performance of the alternatives.

In addition, cost of installation is higher—and may be a factor in how often States use the sinusoidal rumble strip—because the shape requires continuous milling, which is a slower process and wears out the cutting heads more quickly.

Sinusoidal (Mumble) Designs Field Tested on MN 18

Strip 1: Single row on center line.
Width: 14 inches (36 centimeters)
Depth: 0.0625 inch (0.16 centimeter) (high point) to 0.375 inch (0.95 centimeter) (low point)

Depicts an optimal sinusoidal rumble strip for Minnesota.

Strip 2: Two rows straddling center line.
Width: 8 inches (20 centimeters)
Depth: 0.0625 inch (0.16 centimeter) (high point) to 0.5 inch (1.27 centimeters) (low point)

Strip 3: Single row on center line.
Width: 14 inches (36 centimeters)
Depth: 0.0625 inch (0.15 centimeter) (high point) to 0.5 inch (1.27 centimeters) (low point)

Strip 4: Two rows straddling center line.
Width: 8 inches (20 centimeters)
Depth: 0.0625 inch (0.16 centimeter) (high point) to 0.375 inch (0.95 centimeter) (low point)

Note: All four sinusoidal strips had a 14-inch (36-centimeter) wavelength and vertical edges.
Photos: MnDOT.

The MnDOT study concluded that this single-row, 14-inch (36-centimeter) sinusoidal rumble strip is the optimal design for balancing the agency's top three objectives: reducing noise, providing warning for errant motorists, and allowing safe traversability for motorcyclists and bicyclists. The depth is 0.0625 inch (0.16 centimeter) at the high point and 0.5 inch (1.27 centimeters) at the low point. *Photo: MnDOT.*

"There could be a 30 percent increase for small projects to account for the additional labor and cleanup costs," says John Holbert, director of sales and marketing with Surface Preparation Technologies LLC. "Additional traffic control expense should also be anticipated due to the slower milling process."

These extra costs may mean a finite number of safety dollars would not add as many miles of sinusoidal rumble strips as the traditional cylinder shape. However, the reduced noise concerns may make it possible for installations of sinusoidal rumble strips where the traditional shape would not be publicly acceptable, thereby extending the reach of this life-saving safety measure.

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Cathy Satterfield is a safety engineer at FHWA's Office of Safety focusing on reducing roadway departures and improving visibility. She holds a B.S. in civil engineering from the University of Minnesota and a professional engineer's license in Idaho.

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The authors would like to thank Bruce Rymer for his contributions to the article.

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 Announces Mayors' Challenge Winners

In September 2016, local elected officials and their staff from communities across the country gathered at USDOT's headquarters in Washington, DC, for the 2016 Summit for Safer People, Safer Streets. At the summit, U.S. Secretary of Transportation Anthony Foxx recognized the winners of the Mayors' Challenge Awards, which acknowledge some of the most impressive accomplishments communities have made toward improving pedestrian and bicycle safety during the challenge.

This event marks the culmination of the Mayors' Challenge for Safer People, Safer Streets, in which mayors, elected officials, and other local leaders from 245 communities across the United States signed on to improve safety for pedestrians and bicyclists. Communities accepted the challenge by forming local action teams to advance pedestrian and bicycle safety and accessibility and taking local action on one or more of seven challenge activities.

New York, NY; South Bend, IN; and Washington, DC, received the Secretary's Award for Overall Success. Secretary Foxx also recognized Austin and Brownsville, TX, as winners in the Ladders of Opportunity category, and Myrtle Beach, SC, in the Engagement category. In addition, communities were recognized for each of the seven challenge activities, such as gathering and tracking biking and walking data, and improving safety laws and regulations.

For more information, visit www.transportation.gov/mayors-challenge/awards-and-results.

Deputy Administrator Celebrates TIM Training Milestone

Deputy Federal Highway Administrator David Kim recently led a ceremony marking the training of 200,000 emergency responders in traffic incident management (TIM). The life-saving training is part of a national effort to improve the safety of first responders and others on the scene of highway crashes. First responders who have completed the training represent all 50 States, the District of Columbia, and Puerto Rico.

"This training is vital to the men and women who arrive at the scene of a highway crash who often risk their own lives bringing safety and care to others," says Secretary Foxx. "Besides protecting emergency workers and ensuring crash victims receive immediate attention, these practices reduce the chance of secondary crashes and prevent traffic jams by keeping traffic moving for other drivers."

FHWA Deputy Administrator David Kim speaks at a ceremony celebrating the training of 200,000 first responders in traffic incident management.

The delays caused by secondary crashes and other traffic incidents are responsible for about half of all traffic delays—which limits freight movement, increases worker commute times, and significantly decreases highway safety for everyone on the road.

FHWA's responder training course, designed by and for responders, helps to build teams of well-trained police, firefighters, highway workers, emergency medical providers, and towing personnel. Together, they learn a common set of practices, including quick clearance techniques that improve communications and reduce the amount of time needed on scene.

For more information, visit www.fhwa.dot.gov/innovation/everydaycounts/edc-2/tim.cfm.

Technical News

USDOT Launches National Transit Map

Secretary Foxx recently announced the launch of the open data platform for the Bureau of Transportation Statistics' first National Transit Map. Improving connectivity for U.S. workers and travelers requires accurate data about where transit stops are, how frequent transit service is, and where transit routes reach.

Many transit agencies actively publish local data, but previously there was no single source for transit service across the country. USDOT's goal in compiling this transit database is to construct a national dataset for research, planning, and analytical purposes.

The database provides information from 270 transit agencies and includes almost 400,000 stops and stations on nearly 10,000 routes. The data may be useful to app developers, transportation practitioners, advocates, and transit users. Transit planners and advocates might use the information to identify gaps in service and work to better connect their communities. In addition, businesses may use it to determine new opportunities along transit routes.

For more information, visit www.rita.dot.gov/bts/ntm.

Connected Vehicle Pilot Enters Phase Two

USDOT awarded three cooperative agreements collectively worth more than $45 million to initiate the design-build-test phase of the Connected Vehicle Pilot Deployment Program. Selected in 2015, the Connected Vehicle Pilot sites are New York City; Tampa, FL; and Wyoming.

In the first phase of the effort, each site prepared a comprehensive deployment concept to ensure a rapid and efficient rollout. For the second phase, the three sites begin a 20-month period of activity to design, build, and test the Nation's most complex and extensive deployment of integrated wireless invehicle, mobile device, and roadside technologies.

Managed by the Intelligent Transportation Systems Joint Program Office, the Connected Vehicle Pilot Deployment Program is a national effort to deploy, test, and operationalize cutting-edge mobile and roadside technologies and enable multiple connected vehicle applications. These technologies and applications have been brought together in innovative ways to have an immediate impact—saving lives, improving personal mobility, enhancing economic productivity, reducing environmental impacts, and transforming public agency operations.

For more information, visit www.its.dot.gov/pilots/index.htm.

Policy and Legislation

New Standards Set for Commercial Vehicles

Secretary Foxx and U.S. Environmental Protection Agency (EPA) Administrator Gina McCarthy recently signed new environmental standards for medium- and heavy-duty vehicles. The regulation sets standards for greenhouse gas emissions and fuel efficiency for vehicles in model years 2018 through 2027.

The commercial trucking industry hauls about 70 percent of all freight in the United States and is the Nation's second largest segment of U.S. transportation in terms of emissions and energy use, after passenger cars and light trucks. The new standards promote cleaner and more fuel-efficient trucks, and are expected to lower carbon dioxide emissions by 1.2 billion U.S. tons (1.1 billion metric tons), save vehicle owners $170 billion in fuel costs, and reduce oil consumption by up to 2 billion barrels over the lifetime of the vehicles sold under these standards. The additional cost of a new truck will be recouped within 2 to 4 years, saving truck owners more in the long term.

The performance-based standards provide multiple technological pathways to compliance, so that manufacturers can choose the technologies that are right for their products and customers. This enables manufacturers to comply with the standards while providing vehicles with different mixes of engine, transmission, aerodynamic, tire, and mass reduction technologies to meet customer needs.

For the first time, the rules cover trailers as well as tractors—ensuring that innovation will continue in aerodynamic features, next-generation tires, and other features so that trailers can contribute to fuel and emissions savings. The standards also apply to school and commuter buses; vehicles like snowplows, garbage trucks, and delivery vans; and heavy-duty pickup trucks and large passenger vans.

For more information, visit www3.epa.gov/otaq/climate/regs-heavy-duty.htm.

U.S. EPA

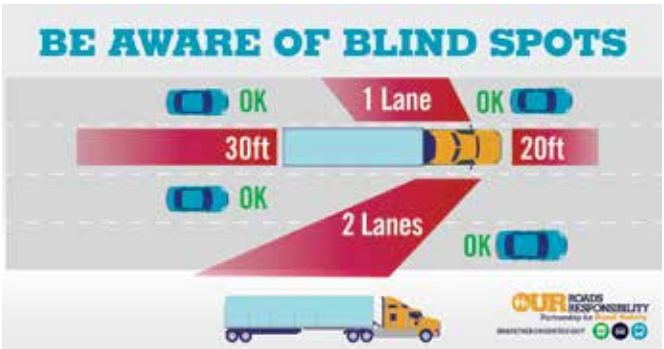
EPA Administrator Gina McCarthy and Transportation Secretary Anthony Foxx recently signed new regulations for greenhouse gas and fuel efficiency standards for commercial vehicles.

Public Information and Information Exchange

FMCSA Campaign Focuses on Commercial Vehicle Safety

The Federal Motor Carrier Safety Administration (FMCSA) recently launched a new public education campaign to reduce crashes, injuries, and fatalities involving large trucks and buses on the Nation's roadways. Our Roads, Our Responsibility aims to raise awareness among the public about operating safely around and sharing the road with large vehicles.

Understanding the safety challenges that commercial motor vehicles face, along with some simple adjustments in driving behavior, can help drivers, bicyclists, and



FMCSA is using infographics and illustrations like this one, showing the large size of a truck driver's blind spots, to educate other road users about safely sharing the road. *Source: FMCSA.*

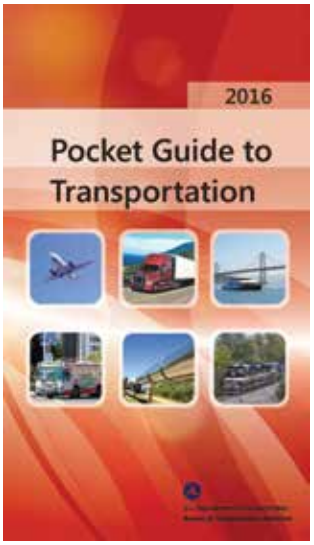
pedestrians avoid dangerous situations and improve safety. For example, large trucks and buses are more difficult to maneuver than average passenger vehicles because of larger blind spots, greater weights and lengths, and longer stopping distances.

The campaign uses consumer-friendly illustrations, radio spots, digital and outdoor ads, and tip sheets to highlight some of these safety challenges. The campaign's Web site contains a variety of resources, including safety tips for pedestrians, bicyclists, passenger vehicle drivers, and commercial vehicle drivers.

Visit www.sharetheroadsafely.gov for more information.

FMCSA

Pocket Guide to Transportation Goes Mobile



The Bureau of Transportation Statistics has developed a smartphone app for the *Pocket Guide to Transportation 2016*. The annual publication is a popular, quick reference guide to significant transportation statistics. The app enables users to access all the informative graphics and tables from the guide without having to carry a physical copy.

The app will include all seven sections of the guide—Infrastructure, Moving People, Moving Goods, Performance, Economy, Safety, and Environment—plus a new Major Trends section. The resource is available from the Apple App Store® for iPhone® and iPad® and from the Google Play™ store for Android™ devices; use keyword "BTS Pocket Guide."

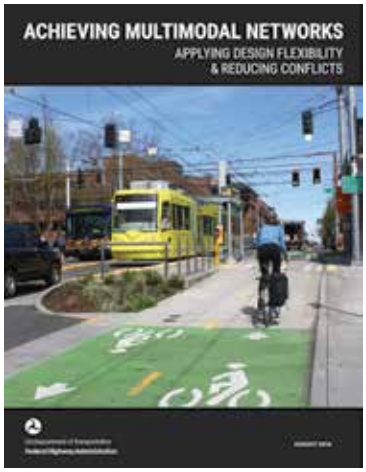
The new app is part of an effort by the Bureau of Transportation Statistics to focus on the use of technology to deliver the most recent transportation statistics in new and innovative ways.

For more information, visit www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/pocket_guide_to_transportation/index.html.

Helping Communities Develop Multimodal Networks

FHWA recently published a resource for practitioners seeking to build multimodal transportation networks. *Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts* (FHWA-HEP-16-055) highlights how to apply design flexibility to address common roadway design challenges and barriers. The publication focuses on how to reduce multimodal conflicts and achieve connected networks so that walking and bicycling are safe, comfortable, and attractive options for people of all ages and abilities.

Multimodal transportation networks provide access to jobs, education, health care, and other essential services in urban, suburban, and rural areas throughout the United States. Interconnected pedestrian and bicycle infrastructure makes walking and bicycling a viable transportation choice for everyone, which contributes to the health, equity, and quality of life of community members.



In many communities, accommodating and encouraging walking and bicycling requires retrofitting an existing transportation system with constrained rights-of-way to include new or enhanced pedestrian and bicycle infrastructure. Greater awareness of the flexibility and versatility available in national guidance will help designers overcome many challenges related to both new and retrofit projects. The guide includes 24 design topics, organized into 2 themes: design flexibility and reducing modal conflicts.

The report is available at www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/part00.cfm.

PBIC Renews and Adds Walk Friendly Communities

The Pedestrian and Bicycle Information Center (PBIC) recently announced that 13 communities renewed their status as Walk Friendly Communities, including Austin, TX, which moved up from bronze to silver designation. In addition, the city of Sebastopol, CA, received bronze recognition for the first time.

City of Sebastopol, CA

Here, a pedestrian crosses a street in a crosswalk in Sebastopol, CA, which recently received designation from PBIC as a Walk Friendly Community.

Launched in 2010, the Walk Friendly Communities program recognizes cities and towns for success in working to improve a wide range of conditions related to walking, including safety, mobility, access, and comfort. Currently, 58 communities across the Nation hold bronze, silver, gold, or platinum designations. The recently renewed cities include Seattle, WA, which remains the only platinum-level community in the program. Ann Arbor, MI; Arlington, VA; Corvallis, OR; Chicago, IL; and Minneapolis, MN, renewed their gold-level designations.

In addition to Austin, Alexandria, VA, and Philadelphia, PA, renewed at the silver level, and Charlotte and Davidson, NC; Flagstaff, AZ; and Wilsonville, OR, renewed at the bronze level.

Applicants use a Web-based program that asks a comprehensive set of questions and provides communities with feedback and ideas for promoting pedestrian safety and activity. The questions deal with engineering, education, encouragement, enforcement, evaluation, and planning.

For more information, visit www.walkfriendly.org/index.cfm.

PBIC

CDOT Thinks Outside the Box for Pedestrian Safety

In 2015, there were 1,330 pedestrian crashes and 59 pedestrian fatalities in Colorado. Seventy-two percent of the crashes occurred at nonintersection locations. To educate pedestrians and drivers on the importance of observing pedestrian laws, the Colorado Department of Transportation (CDOT) recently launched a campaign featuring Fred Estrian, the classic icon of a pedestrian used on walk signals, brought to life.

CDOT

The walk signal icon of a man comes to life in short videos from the Colorado Department of Transportation to educate roads users about pedestrian safety.

Fred Estrian, a play on the word "pedestrian," comes alive in animated short videos that remind road users of the importance of pedestrian safety. From his vantage point in a pedestrian walk signal, Fred sees the results when road users do not follow pedestrian laws. He breaks free from his confines to interact with the people around him and do something to protect the lives of Colorado's pedestrians. CDOT's 15- and 30-second animated shorts highlight Fred's escape and some of the major factors that play a role in pedestrian fatalities.

The videos are available for download at bit.ly/CDOTPedSafety, or view them at www.codot.gov/programs/bikeped/information-for-pedestrians. CDOT has shared them on the agency's social media sites to deliver a serious message with a lighthearted, humorous tone. The campaign also includes stencil art at crosswalks, intersections, and transitional areas like parking garages. The water-soluble stencil art relates key statistics and safety tips to pedestrians and drivers across metro Denver.

CDOT

Personnel

FHWA Researchers Receive ITE Award

The Institute of Transportation Engineers (ITE) recently honored members of FHWA's Office of Operations Research and Development with the Traffic Engineering Council Best Paper Award. Christopher L. Melson, Dr. Cory Krause, and Dr. Joe G. Bared received the award at ITE's 2016 Annual Meeting & Exhibit in Anaheim, CA.

The authors' award-winning paper, "Operational and Safety Characteristics of an Alternative Design, Space-Efficient One-Sided Interchange," presents a distinctive, all-directional system interchange that emphasizes land savings. Using microsimulation and safety software, the researchers analyzed the operational and surrogate safety characteristics of the one-sided interchange and compared the design to an equivalent cloverleaf interchange. The characteristics examined included delay time, throughput, and rear-end and lane-changing conflicts. The results indicate that the one-sided interchange could save more than 43 acres (17 hectares) of land and, using extended entrance merging areas, have comparable operational and safety performance.

For more information about ITE's awards program, visit www.ite.org/awards.

ITE

Reporting Changes of Address

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Internet Watch

by Carrie Boris

The Influence of Mobile Applications

More and more, travelers are turning to smartphone applications for a wide array of transportation activities. Drivers often use apps for vehicle routing, real-time data on congestion, information regarding roadway incidents and construction, and parking availability. Transit users often rely on apps for real-time predictions of transit arrivals. The expanding availability, capability, and affordability of intelligent transportation systems, GPS, wireless, and cloud technologies—coupled with the growth of data availability and data sharing—are causing people to increasingly use smartphone apps to meet their mobility needs.

Many State and local transportation agencies are developing their own apps to provide their stakeholders with useful information and functionality on the go. Many more may be wondering how best to integrate with or support third-party apps and development efforts. To help, the Federal Highway Administration published *Smartphone Applications to Influence Travel Choices* (FHWA-HOP-16-023). This primer provides an overview of current practices and looks toward the future in the evolution and development of smartphone apps for the transportation sector.

Current Challenges

Four types of apps impact transportation—mobility, vehicle connectivity, smart parking, and courier network service—as well as nontransportation apps (such as health, environment and energy consumption, and insurance apps) that may be relevant to travelers. A number of challenges exist for developers, mobility service providers, and public agencies in developing any of these types of apps.

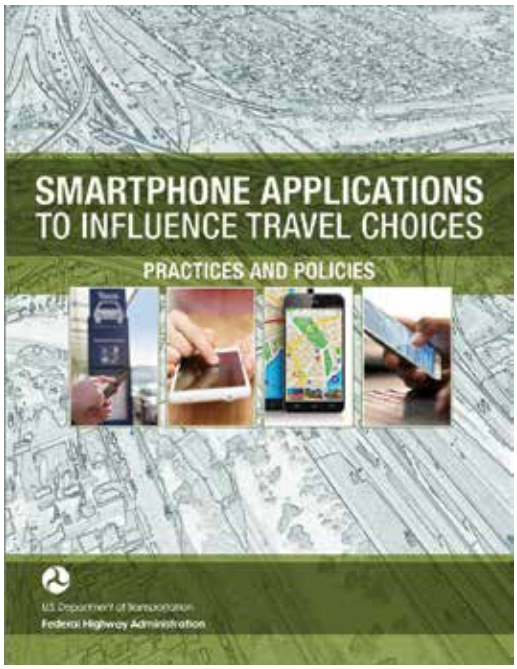
Privacy concerns. Apps may intentionally or unintentionally collect sensitive information that could be exposed by the app itself or through third-party application interfaces and cloud-based data storage.

Open and interoperable data. Data can broadly be divided into three types: (1) open data, (2) proprietary data, and (3) personal data. Open data are publicly available for download or through programming interfaces. Protecting all three types of data, while still enabling information sharing with other apps and services, is a continual challenge confronting developers.

Accessibility considerations. Bridging the digital divide for low-income users, providing service in rural regions with less data coverage, and providing payment options for users without bank accounts represent some of the key accessibility considerations for app-based services. In addition, ensuring that apps are usable by people with varying abilities represents another key challenge for app developers.

Guiding Principles for Public Agencies

Public agencies need to recognize several guiding principles in considering the role and implementation



of smartphone apps on a transportation network. These include enhancing data sharing and interoperability and encouraging multimodal mobility.

To enhance data sharing and interoperability, local governments and public agencies should consider providing open data for app development. Doing so enables them to offer real-time transportation information to their communities, without the cost or responsibility of developing or maintaining mobile applications themselves. Open data can help to ensure data availability, open licenses, and data timeliness.

The primer also recommends that transportation agencies encourage multimodal mobility by enhancing payment mechanisms. With a growing array of private sector trip planning (such as ticketing and fare payment apps), payment is becoming increasingly complex for the end user. Developing a common platform for fare payment with a single point of sale to cover an entire journey (using multiple modes) can make smartphone apps more convenient and encourage multimodal trips. Similarly, expanding commuter benefits also encourages use, by enabling smartphone apps to access pre-tax commuter accounts, offering employer-provided usage, and providing app-based incentives linked to a user's mode of choice.

"Transportation apps are profoundly influencing traveler behavior and how travelers interact with the transportation system," says Wayne Berman, a team leader in FHWA's Office of Operations. FHWA's primer helps agencies navigate this mobile landscape and improve access and functionality for their communities.

For more information, visit www.ops.fhwa.dot.gov/publications/fhwahop16023/index.htm.

Carrie Boris is a contributing editor for PUBLIC ROADS.

by Judy Francis

Studying Human Behavior to Improve Roadway Safety

In 2015, 6.3 million police-reported crashes occurred in the United States. These crashes resulted in 35,092 fatalities and 2.4 million injuries. Although most incidents are attributed to multiple causes, the National Highway Traffic Safety Administration cites human factors as at least one of the contributing causes in approximately 95 percent of crash reports.

Addressing human factors in roadway planning and design can help make roadways safer and reduce the likelihood of these factors contributing to injuries and fatalities. To help engineers, planners, and other transportation professionals increase roadway safety, the National Highway Institute (NHI) created course number 380120, Introducing Human Factors in Roadway Design and Operations.

This 2-day instructor-led training offers a thorough introduction to *Report 600: Human Factors Guidelines for Road Systems*, a National Cooperative Highway Research Program (NCHRP) report focused on road user needs, limitations, and capabilities. The guidelines serve as a resource document for highway designers, traffic engineers, and other safety practitioners by providing objective principles and information on human factors to support and justify design decisions. NCHRP published the first edition of the *Human Factors Guidelines* in three collections from 2008 to 2010. NCHRP released a second edition in 2012.

Connecting Human Factors and Design

Human Factors Guidelines are user-centered strategies developed to help prevent crashes and fatalities caused by driver behavior, ability limitations, and errors. Transportation professionals must take human factors into account to anticipate potential safety issues and mitigate them through the optimal design and installation of roadways, signs, signals, and markings. Examples of human factors include a road user's vision, experience, training, cognitive ability, road familiarity, impairment (such as drugs, alcohol, or fatigue), physical abilities (such as reaction time), and expectations.

Participants enrolled in course 380120 review and discuss the guidelines at length and learn how they apply to road system design and operational decisions. Participants leave prepared to design and maintain safer roadways by examining relevant human factors data and principles.

Course 380120 also describes how the *Human Factors Guidelines* relate to established reference sources such as the *Highway Safety Manual*, the *Manual on Uniform Traffic Control Devices*, and the American Association of State Highway and Transportation Officials' *A Policy on Geometric Design of Highways and Streets*.

When the Missouri Department of Transportation redesigned the I–44/Kansas Expressway interchange, as shown here, it extended the medians to reduce the potential for drivers to enter going the wrong way.

Applying the Guidelines

Throughout the course, participants work through various case studies to apply specific human factors guidelines to real roadway situations. For example, a case study examining issues related to human factors at a local complex interchange would include discussion of how the guidelines could be applied at the location, with group members offering ideas and feedback before completing a followup exercise.

The course also uses videos to demonstrate key concepts, as well as exercises to teach participants how to apply the guidelines once they leave the classroom. During the exercises, participants not only identify how a guideline could be used, but also think through the design implications, safety risks, and consequences of ignoring certain information.

"Participants come to class with very diverse educational and professional backgrounds," says Gabriel Rousseau, safety operations team leader for the Federal Highway Administration. "[They] leave with a better understanding of how individual differences in cognitive and perceptual abilities can impact a road user's experience. They leave knowing how to apply the guidelines as they design new or retrofit existing roadways, which will help them keep more people safe."

NHI recommends this course for engineers, planners, and professionals working for State departments of transportation, metropolitan planning organizations, counties, local municipalities, and consultants for other public agencies. Participants will receive 1.2 continuing education units for successfully completing the course.

Human Factors Guidelines and their proper application are a key part of system design and just one part of the toolbox that roadway designers and operations staff can use to improve overall highway safety.

For more information, including pricing and hosting information, visit NHI's Web site at www.nhi.fhwa.dot.gov. To register for a session or to sign up to receive email alerts when sessions are scheduled, visit the course description page.

Judy Francis is a contracted marketing analyst for NHI.

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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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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).

Analysis of Construction Quality Assurance Procedures on Federally Funded Local Public Agency Projects (Report)
Publication Number: FHWA-HRT-15-008

Approximately 20 percent of the Federal-aid Highway Program is invested annually in infrastructure projects by local public agencies. Previous Federal and State reviews have found significant weaknesses or inconsistencies in assurance practices for construction quality in such projects. In response, this report documents current quality assurance practices from both State departments of transportation and local public agency perspectives.

The report identifies specific issues or areas of weakness in practices for ensuring quality assurance, highlights existing successful practices, and makes recommendations to generally improve construction quality assurance across the full spectrum of local public agency projects and State DOT programs.

State DOTs need to improve oversight of quality assurance procedures and develop practical procedures for local public agencies, while taking into account how to make the process more efficient for the various types, sizes, and scopes of projects that receive Federal funds. Most of the recommendations in the report can be addressed and implemented at the State or project level. Others may require action by the FHWA division office or headquarters. Recognizing that there are significant differences in capabilities and project types for local public agencies, the recommendations consider both large and small agencies and differences among State DOT programs.

The document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/pavements/15008/index.cfm.

The Universal Simple Aging Test (TechBrief)
Publication Number: FHWA-HRT-15-054

The Universal Simple Aging Test (USAT) is a new thin-film short- and long-term aging test developed by the Western Research Institute, with funding and guidance provided by FHWA. This report provides an overview of the USAT, which is an alternative to testing for asphalt binders using standard rolling thin-film ovens and pressure-aging vessels. The USAT is very comparable to these standard testing methods for hot-mix and warm-mix asphalt regarding intermediate- and high-temperature characteristics.

Performing the short-term USAT aging requires 50 minutes, which is 35 minutes less than required by other standard test methods. Cleanup of the equipment after the test also is greatly simplified for the USAT. The time required to perform the long-term component of the

USAT is 8 to 12 hours less than the standard test. The only change in aging for hot-mix asphalt compared with warm-mix asphalt is to adjust the oven temperature from 300 to 265 degrees Fahrenheit (150 to 130 degrees Celsius). Applying the USAT offers several advantages because of its increased simplicity and consistent results.

The document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/pavements/15054/index.cfm.

Active Traffic Management: Comprehension, Legibility, Distance, and Motorist Behavior in Response to Selected Variable Speed Limit and Lane Control Signing (Report)
Publication Number: FHWA-HRT-16-037

Active traffic management incorporates a collection of strategies enabling the dynamic management of recurrent and nonrecurrent congestion based on prevailing traffic conditions. These strategies help to increase peak capacity, smooth traffic flows, and enhance safety on busy major highways.

This report describes four studies (one in a laboratory setting, one in a field setting, and two in a driving simulator) researching two particular active traffic management approaches: variable speed limits and lane control signs. The laboratory study involved participants viewing a series of lane control scenes from the perspective of a driver. Participants described what they thought the signs were intended to mean and what they would do in response to the signs. Subsequently, researchers asked participants which sign content alternatives they preferred. In the related field test, researchers assessed the legibility distance of a selected subset of sign alternatives.

Two experiments conducted in FHWA's Highway Driving Simulator examined how drivers might behave in response to various scenarios employing lane control signs and variable speed limits. The experiments recorded driver lane choice, speed, and eye-glance behavior in a dynamic environment in response to the same signs and scenarios examined in a static environment during the previous field test.

The report synthesizes and summarizes the important contributions made by these studies. The study findings will contribute to the development of guidelines for consistent and effective signing for active traffic management.

Although this document provides useful information on comprehension, preferences, human behavior, and decisionmaking with regard to signing, the *Manual for Uniform Traffic Control Devices* provides official FHWA guidance in this area.

The document is available to download at www.fhwa.dot.gov/publications/research/safety/16037/index.cfm.

Call for Nominations

Is one of your recent projects a model for roadway safety? The Federal Highway Administration and the Roadway Safety Foundation are accepting applications for the 2017 National Roadway Safety Awards. Judges will evaluate nominated projects and programs based on effectiveness, innovation, and efficient use of resources in the following categories:

- **Infrastructure and Operations**
- **Improvements to the Roadway or Roadside That Increase Safety**
- **Program Planning, Development, and Evaluation**—Programs that address State and local needs by making effective use of safety data and evaluations, as well as tools and applications

Deadline for nominations: May 15, 2017.

For application packets, visit http://safety.fhwa.dot.gov/roadwaysafetyawards or www.roadwaysafety.org. For more information, email awards@roadwaysafety.org or call 202–857–1228.

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