Public Roads

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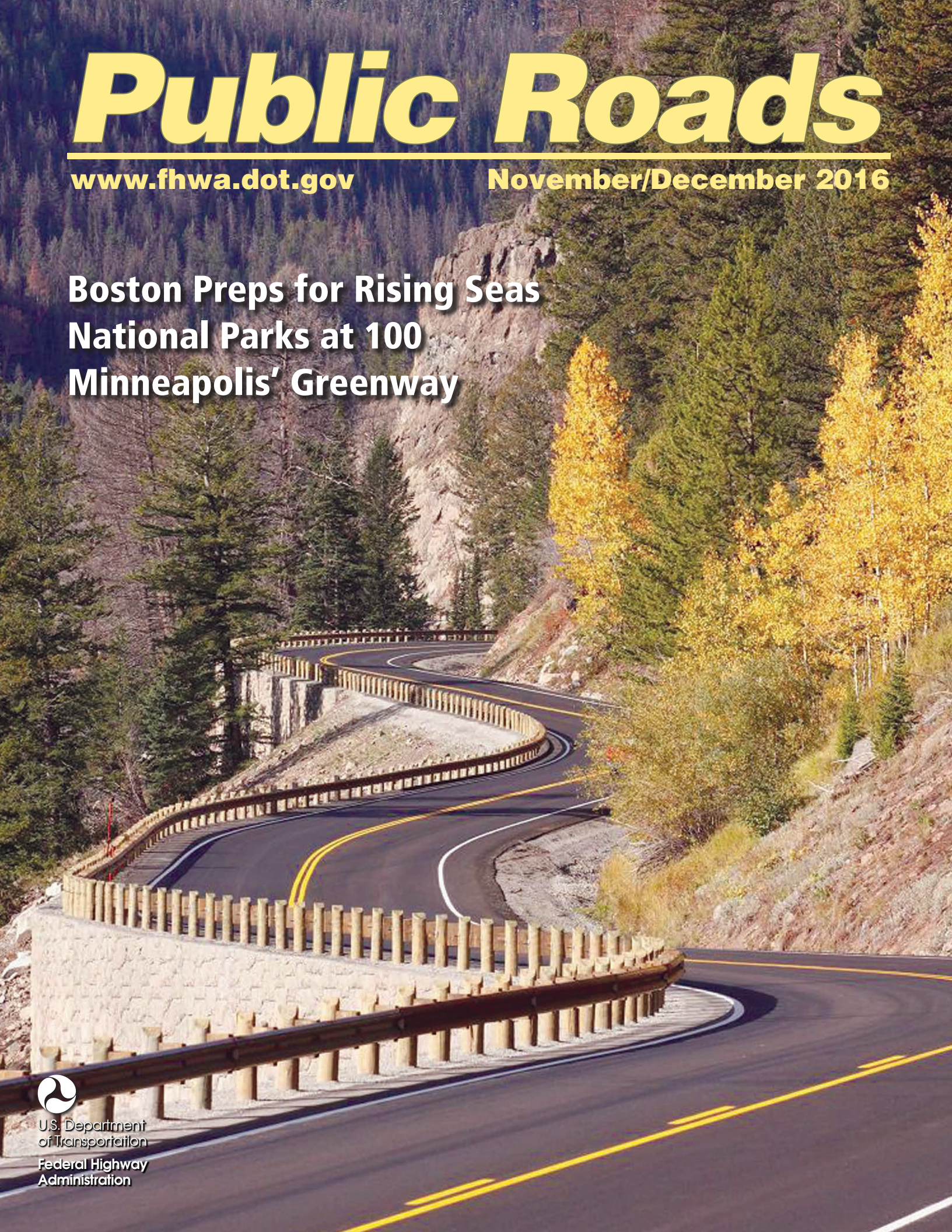
November/December 2016

Boston Preps for Rising Seas
National Parks at 100
Minneapolis' Greenway



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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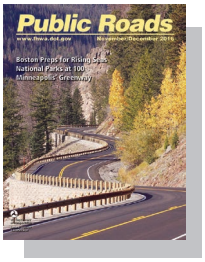

Front cover—Transportation in national parks has come a long way since the National Park Service (NPS) was established 100 years ago. Today's visitors can enjoy many of these natural treasures by driving on safe, modern roadways, such as this one in Yellowstone National Park near Sylvan Pass. A partnership between the NPS and FHWA has helped make these public roads possible. For more information, see "Wondrous Rides Through Nature's Wonders" on page 18 in this issue of PUBLIC ROADS.

Back cover—Early road building crews like this one in Yellowstone National Park in the 1920s endured numerous hardships, such as rugged terrain and exposure to the elements, as they worked to open the door for others to experience America's national parks. As one pioneer road engineer put it, "I am proud to have been associated during my professional career with public works that are so clearly vital to the continued well-being of our Nation and that are also the source of great personal enjoyment to the great majority of our population."

U.S. Department of Transportation
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The electronic version of *Public Roads* can be accessed through the Turner-Fairbank Highway Research Center home page (www.fhwa.dot.gov).

Guest Editorial

Building Safety Into the Infrastructure

Twenty years ago, the Federal Highway Administration embarked on the initial effort to push for a U.S. Department of Transportation policy on reducing total fatalities. The agency decided it would not be satisfied with reductions in fatality rates. At the time, FHWA used the analogy that daily highway deaths equated to a Boeing 737 crashing each day! From that early shock statement, FHWA made real progress in drawing attention to the need to improve highway safety. During the last 18 months, however, safety improvements seemed to have stalled.

Recently, the Centers for Disease Control and Prevention estimated that more than 18,000 lives could be saved each year if the rate of U.S. crash deaths equaled the average rate of highway deaths in 19 other high-income countries. This arresting figure underscores the urgency of developing safety solutions that leverage improvements in the infrastructure and reinforce improved human behavior.

The recent increase in the number of road fatalities is certainly a reminder that there is more work to do. For example, pedestrians accounted for 11 percent of total fatalities in 2005. In 2014, that proportion increased to 15 percent.

Fortunately, the design of transportation systems has evolved from the principle of moving cars on highways to considering how people actually interact with the roadway. For example, improvements to existing roadway features have enhanced both pedestrian and bicyclist safety by making these vulnerable road users more visible to approaching motorists or by physically separating them from vehicle traffic. Similarly, diverging diamond interchanges and restricted crossing U-turns are among low-cost, alternative designs that eliminate the most severe types of intersection crashes by reducing the number of conflict points between vehicles and other users.

A number of tools are available that add greater rigor to the process of selecting and implementing safety countermeasures. For example, using the *Highway Safety Manual* can transform roadway and roadside designs based on precise consideration of their safety consequences. Also, FHWA has developed the Interactive Highway Safety Design Model, a suite of six software modules used to evaluate the safety and operational effects of geometric design decisions.

Research and partnering efforts with States, especially through the Evaluations

of Low-Cost Safety Improvements Pooled Fund Study, continue to explore how to implement safety improvements that reduce fatalities and injuries among all roadway users. Tools that improve driver awareness of pedestrians appear to be promising, as do technologies like the pedestrian hybrid beacon and the rectangular rapid-flash beacon. Both draw attention to the presence of pedestrians and bicyclists far enough upstream so that motorists are more conscious of what they are about to encounter. In addition, FHWA's Turner-Fairbank Highway Research Center is researching connected vehicle technologies that monitor the presence of pedestrians and bicyclists, and the Connected Vehicle Pilot Deployment and Smart City programs feature these technologies.

In sum, FHWA program and research managers are proactive in elevating the state of the practice that will lead *Toward Zero Deaths*! The combined efforts in research, program delivery, technology transfer, technical assistance, and the integration of safety performance into all decisions about highway investments will yield dividends that benefit all transportation users. We at FHWA encourage you to seek out and use the tools that are there for your use.

And by all means, buckle up, don't drive distracted, and remain safe.

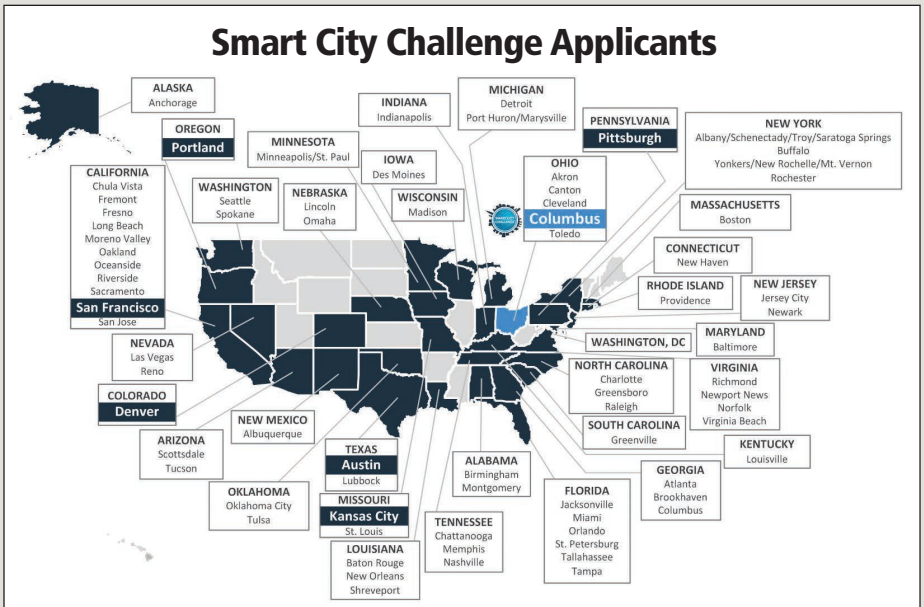
Michael F. Trentacoste
Associate Administrator
Office of Research, Development, and Technology
Director
Turner-Fairbank Highway Research Center
Federal Highway Administration

by Brian Cronin

Smart City Challenge Promotes Innovation in Government

The Smart City Challenge generated a significant amount of interest among U.S. cities. The U.S. Department of Transportation received 78 applications—one from nearly every midsized city in the country.

The challenge required the cities to boldly envision new solutions that would change the face of transportation in U.S. cities by closing the gap between rich and poor, capturing the needs of both young and old, and bridging the digital divide through smart design so that future transportation meets the needs of all city residents.



Source: U.S. Department of Transportation.

How Did the Challenge Come About?

The Nation is at a turning point. The transportation system requires major investments to keep up with the needs of the traveling public and freight carriers. At the same time, technology is evolving rapidly, leading new private sector parties to enter the transportation ecosystem in innovative ways, such as offering app-based ride-hailing services.

In October 2015, USDOT officials started an internal discussion on how to build on what was learned from preparing the report *Beyond Traffic 2045: Trends and Choices*. Department officials decided to leverage resources from research on intelligent transportation systems and use the leadership of the Office of the Secretary to initiate a Smart City Challenge. The goal was to move fast, be bold, and unleash the innovative ideas resident in U.S. cities.

On December 7, 2015, USDOT announced the Smart City Challenge. Each city that wished to compete could submit a proposal of up to 30 pages outlining a high-level vision for the opportunity to win $100,000 to further develop its concept, and ultimately to become the $40 million winner.

The goal was to make it simple to apply for the grant and to reward innovation. The solicitation did not require a local match, but required cities to move fast. With proposals due in 60 days, USDOT provided technical assistance through an inperson workshop and a series of webinars on 12 key vision elements.

A panel of agency experts reviewed the proposals, and, in March 2016, the Secretary of Transportation announced seven finalists: Austin, TX; Columbus, OH; Denver, CO; Kansas City, MO; Pittsburgh, PA; Portland, OR; and San Francisco, CA.

Each finalist had either proposed to create new first-of-a-kind corridors for autonomous vehicles to move city residents, or to electrify city fleets, or to collectively equip more than 13,000 buses, taxis, and cars with vehicle-to-vehicle communications.

Cities were the target audience, but public-private partnerships were essential to success. The Department announced partnerships that add $13.5 million plus additional goods and services from some of the most innovative companies in the private sector, including launch partner Paul G. Allen's Vulcan Inc., cloud partner Amazon Web Services, NXP® Semiconductors, Mobileye, Autodesk, Alphabet's Sidewalk Labs, AT&T, DC Solar, and Continental Automotive.

In addition, the seven Smart City finalists were able to leverage the possibility of winning USDOT's $40 million grant to raise a potential additional $500 million in total. The vast majority of these funds came from a diverse group of more than 150 partners. These partnerships illustrate the private sector's enthusiasm to help build an inclusive transportation system of the future.

The Winner

On June 23, U.S. Secretary of Transportation Anthony Foxx announced the selection of Columbus, OH, as the winner of the Smart City Challenge. As winner, Columbus will receive up to $40 million from USDOT and up to $10 million from Vulcan to supplement the $90 million that the city has already raised from other private partners to carry out its plan. Using these resources, Columbus will work to reshape its transportation network to become part of a fully integrated system that harnesses the power and potential of data, technology, and creativity to reimagine how people and goods move throughout the city.

"Each of the seven finalists put forward an array of thoughtful, intelligent, and innovative ideas that defined a vision for the future of the American city and formed a

> *"The Smart City Challenge required each city to think about transportation as cross-functional, not in silos, but as a transportation ecosystem."*
> *—U.S. Secretary of Transportation Anthony Foxx*

blueprint to show the world what a fully integrated, forward-looking transportation network looks like," said Secretary Foxx in a press release.

Secretary Foxx continued, "The Smart City Challenge required each city to think about transportation as cross-functional, not in silos, but as a transportation ecosystem. The bold initiatives they proposed demonstrated that the future of transportation is not just about using technology to make our systems safer and more efficient—it's about using these advanced tools to make life better for all people, especially those living in underserved communities. While Columbus is the winner of the challenge, we believe each city has come out of this process with a stronger sense of how to address transportation challenges with technology and innovation."

Columbus Mayor Andrew Ginther added, "We are thrilled to be America's first Smart City. Our collaboration between public, private, and nonprofit sectors is the perfect example of how we lift up our residents and connect all communities. Smart Columbus will deliver an unprecedented multimodal transportation system that will not only benefit the people of central Ohio, but potentially all midsized cities. I am grateful to President Obama, Secretary Foxx, the U.S. Department of Transportation, all of our partners, and especially the Smart Columbus team."

Columbus put forward a holistic vision deploying three electric self-driving shuttles to link a new bus rapid transit center to a retail district, connecting more residents to jobs. Columbus also plans to use data analytics to help improve health care access for a neighborhood that currently has an infant mortality rate four times the national average.

City of Columbus

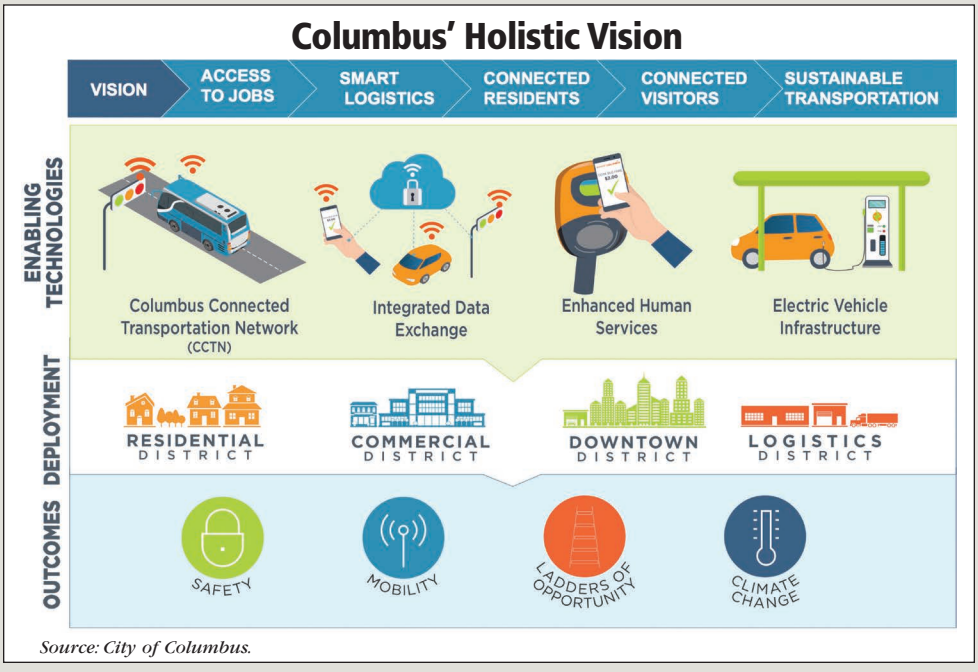
This artist's rendering shows Columbus' smart shuttle service to a new transit center.

USDOT and its Federal partners, including the Department of Homeland Security, Department of Energy, and the National Institute for Standards and Technology, have committed to continue working collaboratively with all seven finalist cities to identify potential Federal, State, local, and private resources to help carry out their Smart City plans. In addition, Vulcan has announced a new commitment to provide additional funding to support the climate and electrification efforts of all seven cities.

What Was Learned?

From these applications, the key takeaways are that nearly half of the cities proposed an autonomous low-speed shuttle or pod-car system, shared-use solutions, the use of data to improve freight operations, and the installation of charging stations for electric vehicles. They also proposed new sensors to monitor vehicle traffic, parking availability, and even pedestrian and bicyclist counts.

Currently, USDOT is analyzing the seven finalists' applications in order to release additional lessons learned. For more information, visit www.transportation.gov/smartcity.



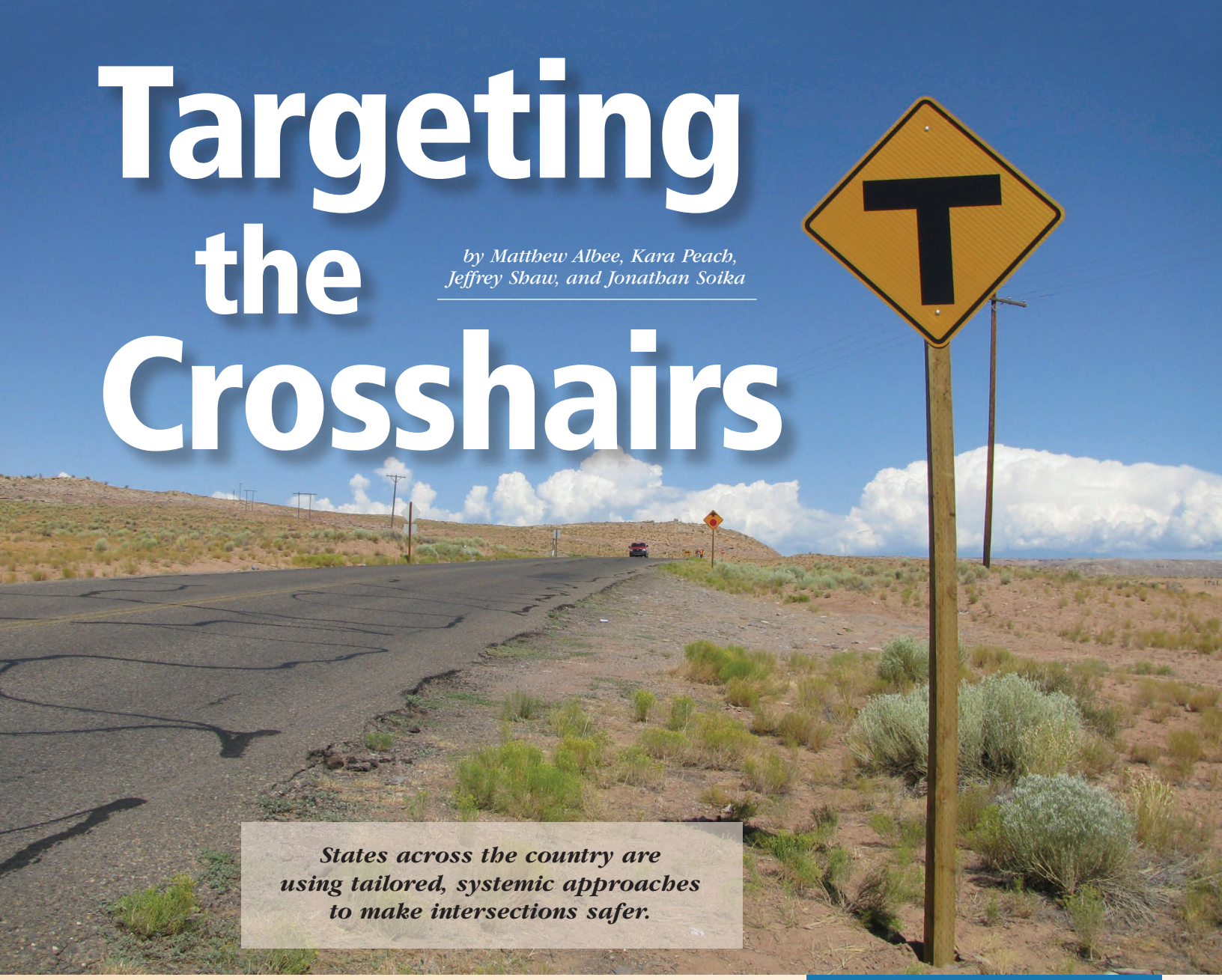
Source: City of Columbus.

Brian Cronin is director of FHWA's Office of Operations Research and Development.

Note: A multimodal team organized from the Office of the Secretary, headed by Mark Dowd, senior advisor to the Secretary, led the Challenge process.

Targeting the Crosshairs

by Matthew Albee, Kara Peach, Jeffrey Shaw, and Jonathan Soika



States across the country are using tailored, systemic approaches to make intersections safer.

(Above) States are using strategic planning to guide deployment of safety improvements at intersections, such as low-cost countermeasures like this intersection warning sign on a rural road in Utah. *Photo: Frank Gross, VHB.*

Crashes at intersections are one of the leading causes of highway fatalities. In 2014, intersection crashes alone resulted in 8,664 fatalities out of the 32,675 total roadway deaths that year. As a means to address traffic-related fatalities and injuries on the Nation's roadways, the Federal Highway Administration's Office of Safety employs a focused approach to safety. This approach is built around three technical focus areas—roadway departures, intersections, and pedestrians/bicycles—and prioritizes resources and efforts to help States and local agencies address their road safety needs. More specifically, the Intersection Safety Program focuses on the many variables that influence safety at intersections, from behavioral factors and special users to intersection design and facility type.

One of the key tools that falls under this program is the Intersection Safety Implementation Plan (ISIP), which can be instrumental in helping transportation agencies reduce intersection-related traffic injuries and fatalities. States develop ISIPs as a way to include intersection safety in their Strategic Highway Safety Plan, either as a standalone emphasis area or integrated across various emphasis areas. Although a State's Strategic Highway Safety Plan might identify some strategies for improving intersection safety, the ISIP establishes more detailed implementation activities, countermeasures, strategies, deployment levels, implementation steps, and required funding.

"The ISIPs can become the blueprint for advancing intersection safety across a State," says Tim Taylor, safety engineer in the FHWA Resource Center. "It's a proven approach to achieve incremental safety improvements to hundreds of intersections in a relatively short time. Eventually, enough small safety improvements can begin to have a profound cumulative impact."

Identifying Barriers And Opportunities

Since 2012, FHWA has engaged with staff from State departments of transportation that have ISIPs through both one-on-one and peer group discussions to hear about their experiences and lessons learned. Through these discussions, FHWA officials realized that States faced similar issues, but their solutions were as varied as the States themselves.

FHWA even found that some DOTs were employing strategies that could address an issue reported by a different State. For example, States often cite limited data as one of the most common barriers to developing an ISIP. The Texas Department of Transportation (TxDOT) is working with local agencies to address this issue—a strategy other States might be able to replicate. FHWA's goal is to create more awareness of various approaches to encourage others to either develop or update an existing ISIP.

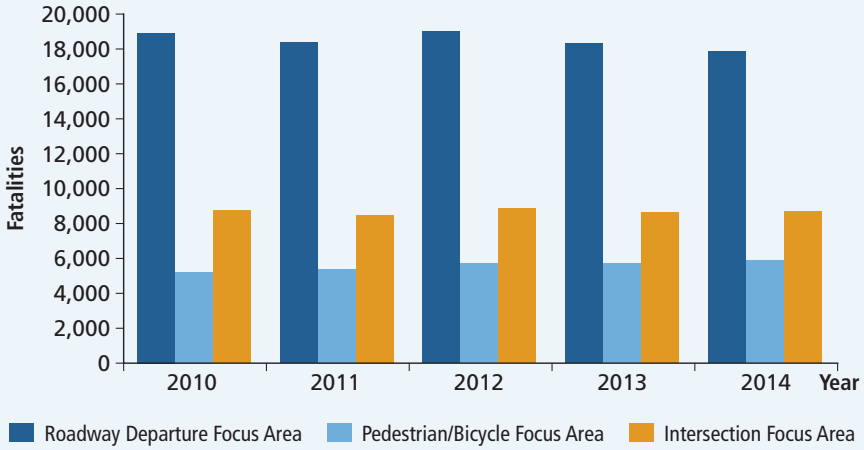
Traditionally, States implement intersection improvement projects at locations with the greatest number of crashes (the hotspot approach) or by deploying countermeasures at all at-risk locations (the systemic approach). The systemic approach deploys countermeasures at locations with the greatest *risks* for crashes rather than at the locations of actual crashes.

The risk factors at intersections are associated with focus crash types and facility types. For example, risk factors associated with angle crashes (focus crash type) at unsignalized intersections (focus control type) along rural, two-lane roads (focus facility type) could include visibility on the approach to the intersection; conspicuity of the intersection; sight lines and distances between legs of the intersection; and presence, condition, types, and sizes of signs and pavement markings.

To advance the systemic approach further—for intersection safety and other priority areas—FHWA developed the Systemic Safety Project Selection Tool. The tool provides transportation agencies with step-by-step guidance on conducting a systemic safety analysis.

Many States are adding a systemic component to their Highway Safety Improvement Programs. The States range in size, number of roadway miles owned, and progress. Yet their stories—from development to implementation and evaluation—highlight the notion that all States can apply and adapt the ISIP process to their needs.

National Fatalities Between 2010 and 2014



Source: FHWA.

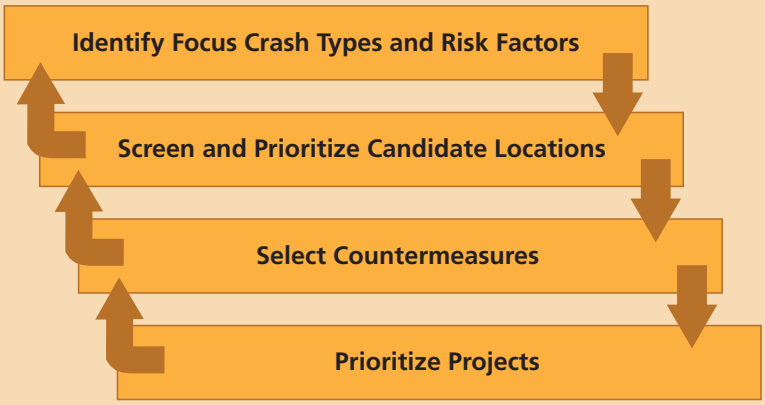
Data from FHWA's Roadway Safety Data Dashboards show the breakdown of national fatalities between 2010 and 2014 for three main focus areas: roadway departure, pedestrian/bicycle, and intersection.

Understanding the Systemic Approach to Safety Planning

The systemic approach to safety is a three-pronged approach: (1) analyze systemwide data to identify a problem, (2) look for similar risk factors present in severe crashes, and (3) deploy one or more low-cost countermeasures based on the risk factors to address the underlying circumstances contributing to crashes.

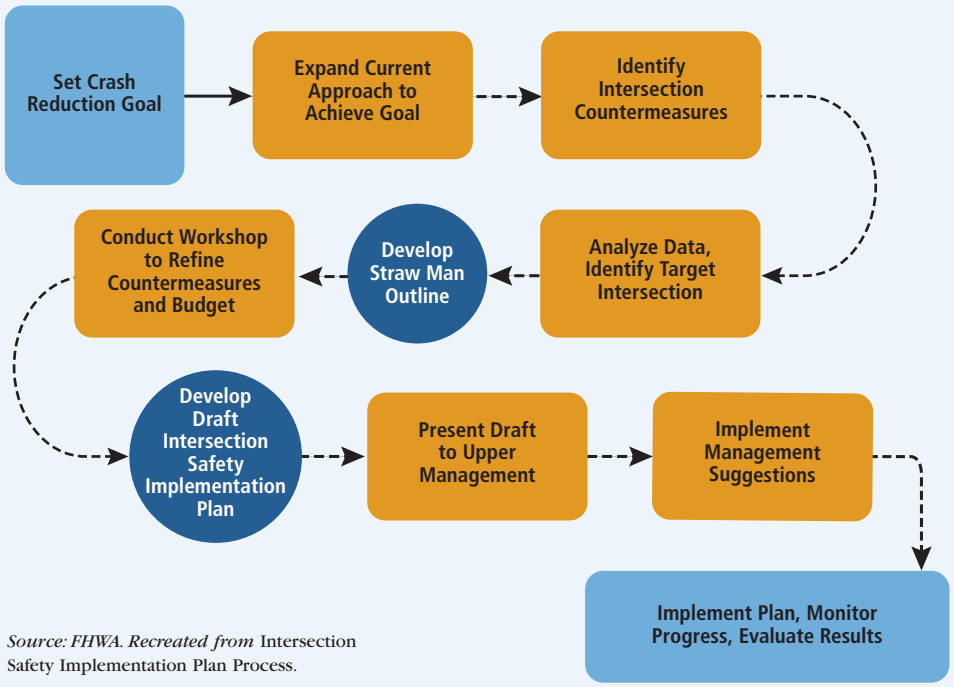
FHWA developed the Systemic Safety Project Selection Tool to assist transportation agencies in conducting systemic safety planning. The tool provides a step-by-step process and guidance for determining the distribution of safety countermeasures using a systemic versus hotspot approach. Even States with limited data can use this tool, because they can tailor it to fit the available data.

The tool is available at http://safety.fhwa.dot.gov/systemic.



Source: FHWA.

Process for Developing an ISIP



Source: FHWA. Recreated from Intersection Safety Implementation Plan Process.

Developing an ISIP

As is true with many plans, the development stage is the most important because it lays the groundwork for the future. One of the earlier documents on using a systemic approach, FHWA's *Intersection Safety Implementation Plan Process* (FHWA-SA-10-010), provides a template for developing an ISIP. The template details the activities, countermeasures, strategies, deployment levels, implementation steps, and funding scenarios needed to advance intersection safety. From setting a goal for the reduction of intersection crashes to developing a draft plan, the actionable steps detailed in the document set the stage for future success and enable States to anticipate and plan for future issues.

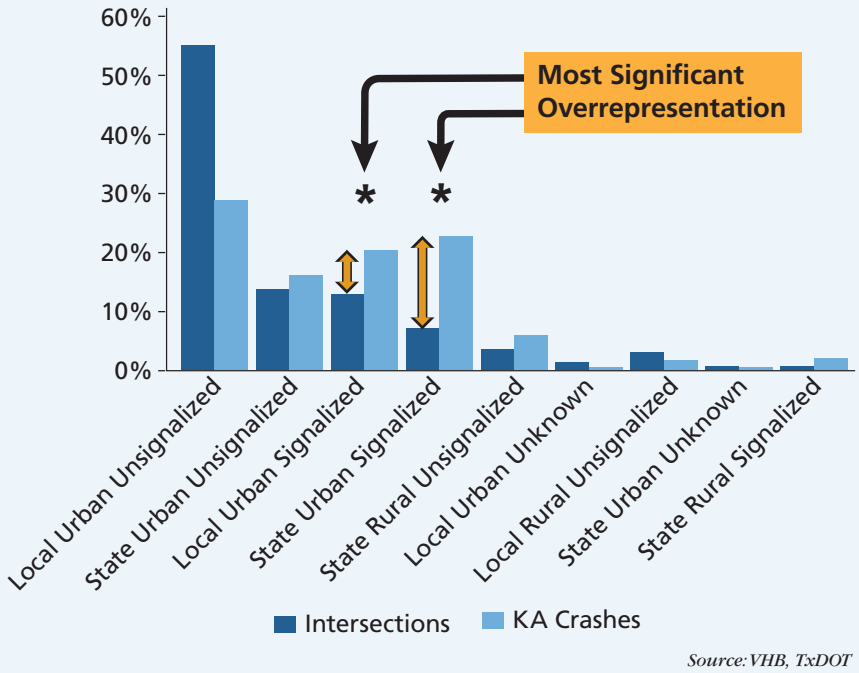
Several States with ISIPs noted that early buy-in from decisionmakers and integration with other statewide plans were essential to the success of their ISIPs. One strategy to strengthen the support on a statewide level is to integrate the ISIP with the Strategic Highway Safety Plan or other similar statewide planning documents. Several States—Mississippi, Missouri, and North Carolina, among others—specifically identified intersection crashes as an emphasis area in their Strategic Highway Safety Plans.

For example, in Tennessee, intersection safety is a subset of the State's Infrastructure Improvements Emphasis Area, which is included in its Strategic Highway Safety Plan.

Similarly, Florida found that integrating the ISIP into its Strategic Highway Safety Plan was a useful strategy for advancing low-cost countermeasures into the plan. This, in conjunction with a statewide coalition focused on intersections and roadway departure, has driven implementation.

Florida's neighbor is another example: Before the Georgia Department of Transportation (GDOT) finalized its plan in 2010, the State had established a strong partnership with the Governor's Office of Highway Safety—a relationship that established engineering as

Intersection Crashes in Texas



Source: VHB, TxDOT

Initial analyses of data on fatal/incapacitating injury (KA) crashes in the five largest urban regions in Texas by area type and traffic control revealed that State and local urban signalized intersections had the most significant overrepresentation when comparing the proportion of total intersections having a crash to the proportion of KA crashes. Therefore, TxDOT focused its ISIP on those locations.

a key piece of the State's Strategic Highway Safety Plan and enabled seamless integration of the ISIP.

An ISIP is a data-driven plan, and the systemic approach to intersection safety requires accurate and up-to-date roadway, crash, and other data files. Many transportation agencies that own a large portion of roadway mileage report having strong roadway data systems, but they still face many hurdles with crash data, such as identifying and filling gaps and the timeliness of data.

For example, TxDOT initiated its ISIP in 2015 using its robust Crash Records Information System® as the basis for prioritizing projects. Once the TxDOT staff members identified the gaps in data, they worked with other transportation agencies at the State and local levels to develop strategies to address the issues. The efforts in Texas have strengthened both the data systems and the relationships with local agencies.

"Crash data currently drive the effectiveness of our ISIP, and we will continue to collect roadway characteristic data from the local transportation agencies and [metropolitan planning organizations]," says Carol Rawson, director of traffic operations with TxDOT. "By providing traffic volumes and other roadway characteristic data to TxDOT in a timely manner, our local partners recognize the benefit of obtaining additional ISIP dollars in the future."

Various Approaches By States

Some States continue to grow awareness of the need for ISIPs and supporting data, but other DOTs with limited ownership of intersections are still debating the merits of a statewide intersection plan. Not in Pennsylvania, however. The Pennsylvania Department of Transportation (PennDOT) is a decentralized agency, but it integrated an ISIP with its Highway Safety Improvement Program policies and funding procedures during the planning phases, which ties implementation to funding. PennDOT districts receive Highway Safety Improvement Program funding, and they are responsible for implementing the countermeasures. The districts use the ISIP to confirm locations and countermeasure packages, and throughout the process, they work closely with the metropolitan and rural planning organizations as they implement the systemic safety improvements at intersections involving State highways.

MoDOT installed this "Watch for Entering Traffic" sign on a suburban street near Tunas, MO. Vehicles activate the sign's flashing beacons by driving over loops in the roadway. This installation is an example of a low-cost safety measure. *Photo: MoDOT.*

By integrating the ISIP within the Strategic Highway Safety Plan and detailing an implementation strategy, PennDOT was poised for action when the funding became available. However, PennDOT exhausted its project list more quickly than anticipated after proceeding with mostly low-cost projects. PennDOT's next task is to determine how to continue implementing the systemic approach while maintaining an up-to-date project list within the ISIP.

The Missouri Department of Transportation (MoDOT) took a slightly different approach in developing its ISIP, providing a degree of flexibility that could be useful to States like Pennsylvania. As John Miller, traffic liaison engineer with MoDOT, explains, "Missouri adopted most of the intersection plan, with the exception of the timeline to implement. This allows the plan to be flexible and change as the data changes." Miller added that the process provided insight into how to use the systemic approach for intersections, a true benefit for the State.

Similarly, the South Carolina Department of Transportation (SCDOT) uses its 2008 intersection plan as a blueprint for implementation and has not had to revisit or revise the plan in order to establish updated project lists.

Putting Plans Into Action

Efforts to translate planning into real action in the form of projects vary widely among the States with formal ISIPs as well as those with informal intersection plans that are integrated into other documents. The implementation strategies reported by the States include partial systemic, corridor systemic, and full systemic approaches. The progress in some States has been more

Translating ISIPs Into Policy

Although some States may not be progressing with implementation as quickly as desired, they have used the ISIP documentation as an opportunity to develop and implement statewide policies.

For example, MoDOT adopted a signal enhancement effort as part of its signal maintenance cycle to add reflectorized backplates, adjust clearance intervals to be in compliance with the Institute of Transportation Engineers' formula, and if necessary, limit the use of late-night flashing operations. The maintenance schedule also evaluates existing signal heads for inconsistencies with MoDOT standards.

limited because of uncertainty about how far and how quickly to proceed.

Partial systemic treats locations with low-to-moderate crash histories, with a focus on widespread deployment of only low-cost improvement packages. The corridor systemic approach is narrower and focuses on multiple intersections with low-to-moderate crash histories along an extended distance of roadway. The third approach—full systemic—treats intersections entirely on risk characteristics identified through rigorous safety data analysis.

After completing an ISIP in 2009, the Mississippi Department of Transportation (MDOT) used the existence of the plan to add intersections as a critical emphasis area to an update of its Strategic Highway Safety Plan. This was an important step that connected ISIP-related projects to funding opportunities through the Highway Safety Improvement Program. However, both the systemic approach and some of the countermeasures were new to Mississippi at the time. MDOT proceeded with implementation in a more conservative fashion by treating a smaller number of intersections with the low-cost countermeasures outlined in the ISIP, including splitter islands, enhanced signing and pavement markings, and flashing beacons. In addition, MDOT has constructed J-turns at multiple locations (both in-house and as contracted projects) since 2009. Results to date have been positive, and MDOT continues to construct J-turns with more planned into 2017. The DOT also will implement a larger scale systemic deployment of low-cost intersection countermeasures in late 2016.

States with ISIPs commonly report progress with the partial systemic approach—treating some locations with low-to-moderate crash histories, as opposed to only those meeting high crash thresholds. Here, the focus is on widespread deployment of only low-cost packages of improvements, consisting mostly of enhancements to traffic control devices such as oversized signs, wider pavement markings, and traffic signal backplates with retroreflective borders. This partial systemic approach may start slowly, as evidenced in some of the State examples that follow.

In Tennessee, after the DOT completed an ISIP in 2007, progress stalled as TDOT staff consulted peers in other States to seek ideas on how to proceed. After learning more about efforts in other States, TDOT staff developed an intersection checklist and focused on intersections with 8 or more crashes from a list of more than 1,700 intersections identified for sign and marking improvements.

In Louisiana, the transportation department completed its ISIP in 2008, but funding for projects was not immediately available. Fortunately, the U.S. Department of Transportation's Rural Safety Innovation Program provided a one-time grant opportunity in 2008. USDOT selected a proposal by the Louisiana Department of Transportation and Development (LA DOTD) to fund the construction activity for 104 intersections identified in the ISIP. One of the lessons learned from Louisiana is that an ISIP can be a source for shovel-ready safety improvements when additional funding becomes available, or as fill-in projects for unobligated Highway Safety Improvement Program funds.

SCDOT was one of the first agencies to act aggressively on its ISIP using the partial systemic approach. The State focused on the widespread deployment of the low-cost treatment packages for stop-controlled and signalized intersections. The original ISIP identified more than 2,000 intersections for treatment. With funding set aside for deployment, SCDOT improved 700 intersections initially. Lessons learned during the first wave of deployment informed SCDOT's next steps, and the improvements to the next approximately 1,500 intersections that followed.

"The systemic approach for the data analysis allowed SCDOT to clearly define our safety target where over 40 percent of intersection-related crashes were occurring at only 2 percent of State-owned intersections," says Joey Riddle, safety program engineer with SCDOT. "From [there], a systemic implementation allowed us to fast-track our safety improvements by condensing the typical installation timeframe from 20 years to just 3 years."

Beyond a Partial Systemic Approach

The corridor systemic approach picks up where the partial systemic approach leaves off. The corridor approach is based on consistent treatment of multiple intersections along an extended distance of roadway with low-cost enhancement packages. Simply, when multiple

Signal backplates with retroreflective borders and a flashing yellow arrow for left turns at this intersection in Massachusetts are among the common low-cost measures that can help to increase safety.

intersections identified with low-to-moderate crash histories are located along a defined corridor, the transportation community deems that corridor to be a higher risk. In addition, this approach takes into account not only the safety performance, but also mobility and operational performance, adjacent land uses, and context.

Both Georgia and Missouri were able to use the corridors identified in their respective ISIPs to implement innovative projects in intersection design. Both States implemented unsignalized, restricted crossing U-turn intersection designs—also known as J-turns—as corridor improvement projects. The J-turn design is a proven safety treatment for high-speed rural, multilane, divided highways with at-grade intersections. The design has the added advantage of maintaining a high degree of access to minor crossing routes and adjacent properties. Both GDOT and MoDOT replaced several two-way, stop-controlled intersections with J-turns to reduce severe crash scenarios.

In Ohio, the corridor systemic approach was the basis for retiming yellow change and red clearance intervals for traffic signals following the guidance provided in the Institute of Transportation Engineers' *Traffic Control Devices Handbook*. Ohio implemented the retiming along 35 corridors.

The third implementation strategy is the full systemic approach, which differs from the first two categories in that it calls for treating an intersection entirely based on risk characteristics identified through the rigorous analysis of safety data. Because the systemic approach identifies risk factors, there is a need to correlate characteristics of various types to the locations having crashes. These characteristics include traffic operations (for example, traffic volumes, traffic control type, traffic signal phasing, approach speeds), geometrics (for example, number of lanes, number of approaches, median presence and width), land use (for example, rural/urban, driveway presence and density), and others (for example, lighting, pavement condition). The most commonly cited barrier to using the full systemic approach is a lack of data, mostly an inventory of such intersection elements.

Louisiana installed two oversized STOP signs, a low-cost countermeasure, at this stop-controlled, three-legged rural intersection. *Photo: LA DOTD.*

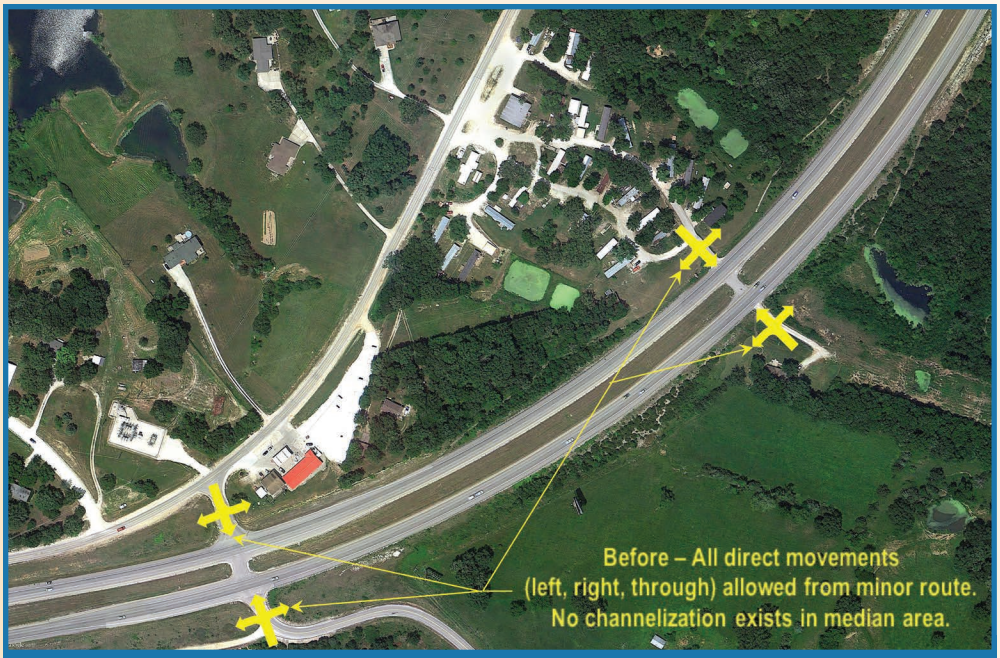
However, the growing familiarity and experience with the partial systemic and corridor systemic approaches is driving an interest in some States to pursue a full systemic approach as better data become available.

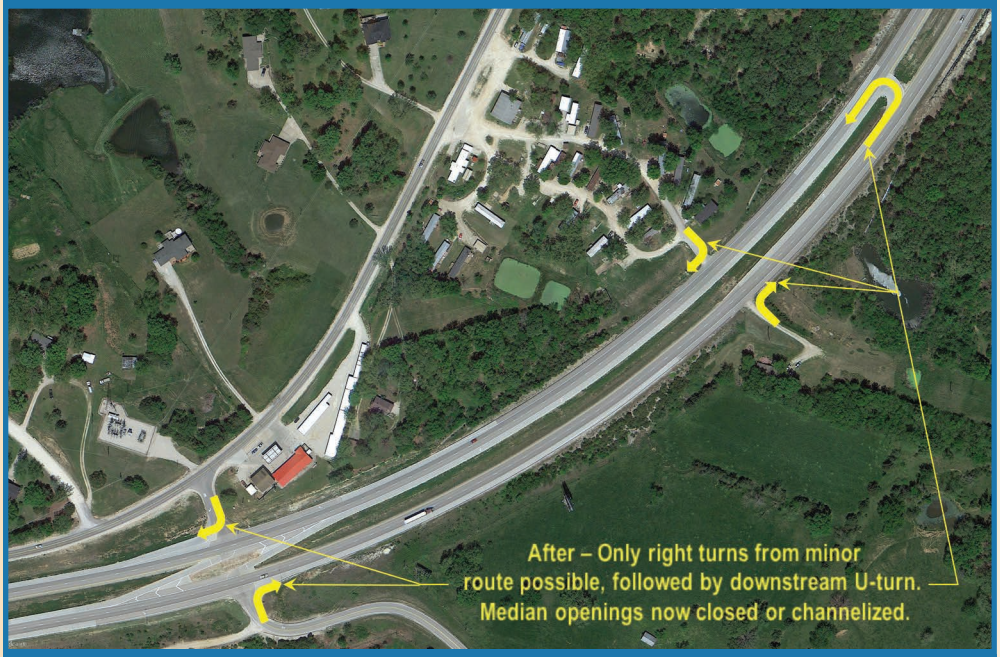
Evaluating Impacts On Safety

Evaluation is a vital part of any safety program, and ISIP projects are no different. However, the widespread nature of some systemic strategies and improvements can make it more difficult to determine cause and effect compared to typical site-specific safety analyses.

For example, the Florida Strategic Highway Safety Plan set a goal for achieving a 5-percent annual reduction in highway crash-related fatalities and serious injuries. The State met that goal during the period following completion of its ISIP, but FDOT was unable to link the decrease as a direct result of intersection improvements. Nonetheless, FDOT staff took the necessary steps to incorporate many of the low-cost safety improvements into Florida's highway standards and policies for all projects.

Fortunately, some States have been able to evaluate the results of their ISIP efforts. The Louisiana deployment described earlier benefited from an evaluation component integrated into the grant program. The evaluation focused on the stop-controlled treatments [such as those generally described in FHWA's





Missouri constructed this restricted crossing U-turn on U.S. 54 in a rural part of the State to reduce the number of conflict points. *Photos: Map data ©2016 Google, Imagery ©2016 DigitalGlobe, U.S. Geological Survey, U.S. Department of Agriculture Farm Service Agency.*

Low Cost Safety Enhancements for Stop-Controlled and Signalized Intersections (FHWA-SA-09-020)] and used techniques and models from the American Association of State Highway and Transportation Officials' *Highway Safety Manual*. It compared 36 treatment sites and 7 untreated sites with 4 years of before data and 2 years of after data. The results were clear. For three-legged, stop-controlled rural intersections, severe (serious injury and fatal) crashes saw a 56-percent reduction. Four-legged, stop-controlled rural intersections showed a reduction of 64 percent in severe crashes.

The experience in South Carolina has been the subject of an ongoing assessment under the Evaluation of Low Cost Safety Improvements Pooled Fund Study. This empirical Bayes evaluation encompasses a 10-year timeframe (2005 through 2014), with low-cost treatments at 84 signalized intersections and 434 stop-controlled intersections. Results for the signalized intersection treatments show a 10.7-percent reduction in fatal and injury crashes and an 11.6-percent reduction in right-angle crashes, both at a 95-percent confidence level. Project evaluators found a 4.5-percent reduction of total crashes at the 90-percent confidence level as well.

Results for the stop-controlled intersection treatments show an 8.3-percent reduction in total crashes, a 10-percent reduction in fatal and injury crashes, 6.7-percent reduction in rear-end crashes, 5.9-percent reduction in right-angle crashes, and 11.1-percent reduction in nighttime crashes. All results for stop-controlled intersections are statistically significant at the 95-percent confidence level with small standards of error.

Although there are marked differences between the results of the two evaluations, it is important to note the difference in the datasets. The South Carolina sample is statewide and largely reflects sites with low-to-moderate crash histories. The Louisiana sample includes fewer sites with more moderate-to-high crash histories. Although the expected crash savings per location may not be as great as with other, higher cost treatments (for example, converting a conventional intersection to a roundabout), the low cost of these treatments means States can treat many more locations, while still providing a competitive, positive benefit/cost ratio.

SCDOT's Riddle reemphasizes this point. "Systemic upgrades through a larger statewide contract ensured uniformity of statewide implementation, gained administrative efficiencies, and

North Carolina installed a roundabout at the entrance to a school on this suburban road. Before the roundabout, the intersection was stop-controlled and saw a high number of crashes. *Photos: Lyle Overcash, VHB.*

realized lower pricing through economy of scale and leveraging our resources," he says.

Using Feedback to Move Forward

The States with ISIPs that provided feedback to FHWA and shared their lessons learned varied in terms of system size and organizational structure. Each also experienced unique organizational challenges. Despite these differences, those that demonstrated the most success from their ISIPs managed to adapt and tailor them to meet immediate needs within their respective States.

For example, some States reported using the ISIP as a prescriptive document that identifies specific project locations and details the countermeasures. Other States have taken a more flexible approach, using the ISIP to inform changes to policies and standards, or informing safety improvements to projects scoped for other reasons.

All the States that provided feedback agreed that ISIPs serve a valuable purpose in introducing the concept of systemic approaches. They also inspire further ideas on how to link Strategic Highway Safety Plans to tangible outcomes funded by Highway Safety Improvement Programs.

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Keeping Climate Impacts at Bay in Boston

by Gina Filosa, Leslie Stahl, Steven Miller, and Katherin McArthur

Massachusetts aims at resiliency for road infrastructure by assessing risks to the Central Artery/Tunnel and protecting it from potential future flooding.

Vehicles are exiting one of the portals of the Thomas O'Neill, Jr. Tunnel in Boston. Most of the tunnel is not vulnerable to flooding currently, but it will become more at risk as climate change continues to raise sea levels. *Photo: MassDOT.*

Although Massachusetts was spared the strongest impacts of Superstorm Sandy, the hurricane served as a wakeup call about the risks of future impacts from climate change on the Commonwealth's coastal infrastructure. Like elsewhere, Massachusetts's climate is changing and will continue to do so over the course of this century.

The Massachusetts Department of Transportation (MassDOT) is faced, as other State DOTs are, with the challenge of adapting infrastructure to the changing climate and extreme weather events. To address this challenge proactively, MassDOT is developing a program that is focused on evaluating the vulnerability of statewide transportation assets to climate-related hazards and creating tools to facilitate resilient highway designs.

Current projects in this resiliency program include a coastal and a statewide assessment of transportation vulnerability and a tool for mapping that vulnerability. In addition, MassDOT published a report in 2015 assessing the risks to Boston's Central Artery/Tunnel. The agency is now creating additional assessment tools and reviewing the adaptation options proposed in the report. This data-driven project has been time and labor intensive, but the results have provided MassDOT with assurances about the Central Artery/Tunnel's stability in the short term and ideas on how to improve its resiliency in the long term.

The Big Dig's Vulnerability

The Central Artery/Tunnel, known to locals as the Big Dig, is a critical link in the regional transportation network and a vitally important asset to Boston and the surrounding communities. In the event of a disaster, the Central Artery is an indispensable route for evacuation, emergency responses, and recovery services.

As evidenced by the impacts of Superstorm Sandy on New York City's tunnel system, infrastructure located near the ocean, as is the case with the Central Artery/Tunnel in Boston, is vulnerable to storm-driven flooding. This vulnerability puts the Boston tunnel at a greater risk of shutting down entirely during extreme weather events. The Central Artery system is especially important because alternative routes, such as surface streets, cannot accommodate the same high traffic volumes, and there are only two additional sets of tunnels that connect downtown Boston to points outside the city.

To protect this essential asset, MassDOT, in partnership with the Federal Highway Administration, conducted an assessment to determine the tunnel's vulnerability. The assessment had three objectives: (1) develop an inventory of all assets in the Central Artery/Tunnel network, (2) assess the vulnerability of the network to sea level rise and potential flooding due to coastal storm surge and wave action resulting from extreme storm events, and (3) investigate adaptation options to reduce identified vulnerabilities and develop plans to mitigate or prevent damage from future storm events. The MassDOT study used FHWA's *Climate Change & Extreme Weather Vulnerability Assessment Framework* (FHWA-HEP-13-005) to guide its approach.

Schematic of Boston's Central Artery/Tunnel System

This map of the Boston Inner Harbor shows the 161-lane-mile (259-lane-kilometer) system, which includes elevated, at-grade, and underground portions.

Collecting Asset Data

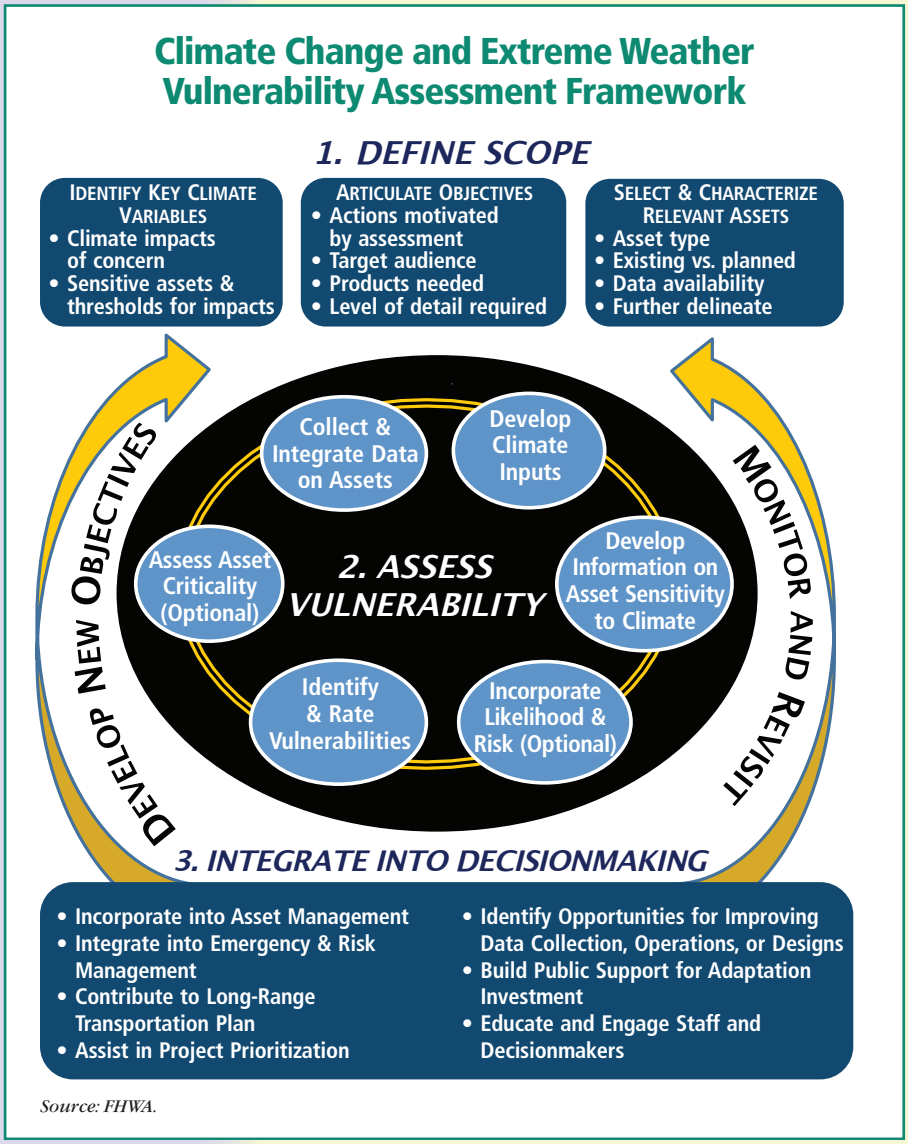
MassDOT began the vulnerability assessment by collecting information on the location and condition of the assets that make up the Central Artery/Tunnel system. The agency compiled asset data from a variety of internal divisional and departmental databases and then reviewed and refined the initial asset list with MassDOT operations and maintenance staff who are familiar with the selected facilities.

During these discussions, staff indicated that the system consists of a number of interdependent components. Considered together, these components make the entire system a critical asset that is worth assessing. Based on the staff's input, the assessment team decided that the system, as a whole, would be included in the vulnerability assessment.

During the initial phase of data collection, the members of the assessment team quickly realized that they needed to confirm some of the existing information, such as elevation data. To collect more detailed information, the team conducted

Climate Change Resilience Pilots

In 2010–2011 and in 2013–2015, FHWA partnered with State DOTs and metropolitan planning organizations to conduct a number of assessments of the vulnerability of transportation infrastructure to climate change and extreme weather. The purpose of these pilots was to help DOTs and metropolitan planning organizations identify vulnerable assets and analyze options for adapting and improving their resiliency to the impacts of climate change. Five teams participated in the first round of pilots, and 19 teams in the second round. The experiences and lessons learned from the first round helped inform FHWA's *Climate Change & Extreme Weather Vulnerability Assessment Framework*, which is an introductory guide for transportation agencies to use to develop an assessment of an asset's or system's vulnerability. Currently, FHWA is updating and expanding the framework based on the results and lessons learned from the second round of pilots.



Source: FHWA.

field visits to take photographs and measure the height of selected assets. To ground-truth (verify in person) the existing elevation information, the team conducted targeted elevation surveys at locations identified as potential flood pathways.

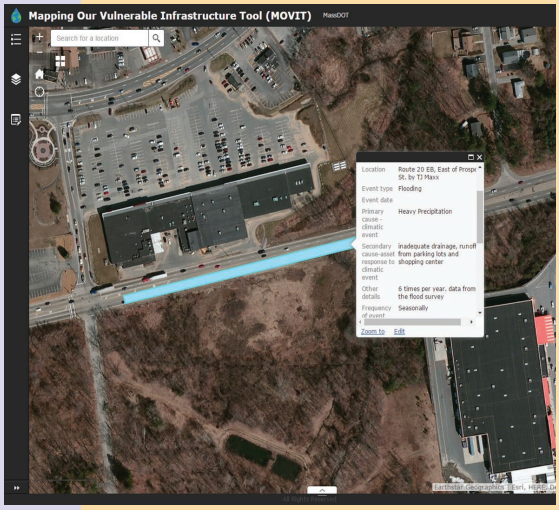
"The field observations and ground-truthing played a large role in our project," says Joseph Rigney, P.E., tunnel engineer with MassDOT. "Through the site visits, we gathered information that wasn't available in our digital data, and in some instances we identified new structures that were not part of our existing asset databases. The information we collected by going out in the field turned out to be essential in assessing vulnerability and later in developing adaptation solutions."

Once the asset data was compiled, the assessment team began developing information on potential flooding due to sea level rise, coastal storm surge, and wave action.

Hydrodynamic Analysis And Mathematical Modeling

Previous vulnerability studies for the Boston area relied primarily on a "bathtub" approach or on simplified empirical or statistical models for assessing the impacts of sea level rise and storm surge on populations and property. The bathtub method applies sea level rise scenarios at constant elevations to model the impacts of coastal

Mapping Our Vulnerable Infrastructure Tool (MOVIT)



MassDOT

Although MassDOT has found complex modeling tools highly valuable for accurately assessing the vulnerability of transportation assets, the agency also recognizes the important role that institutional knowledge plays in identifying vulnerable assets. In addition to modeling and mapping potentially vulnerable transportation assets, MassDOT also wanted to translate staff's on-the-ground experience into useful data. Following the pilot study, MassDOT developed the Mapping Our Vulnerable Infrastructure Tool (MOVIT), a Web-based application that compiles and displays information on the locations and assets that have experienced weather-related problems. To develop MOVIT, the agency's staff conducted interviews and staff surveys to collect information on known flood areas along the highway system. MassDOT plans to train staff to use the tool to capture additional data on weather-related vulnerabilities.

This screenshot of the MOVIT application shows an aerial view of a road (highlighted). Shown in the pullout is the metadata for the area, including information on the location, the climatic event, and the asset's response. Through a Web-based map interface, MOVIT enables users to place a point or an area on the map and enter data to describe weather-related infrastructure vulnerabilities associated with that location.

MassDOT

Shown here are the entrance and exit ramps for the Ted Williams Tunnel, with the Highway Operation Center in the background.

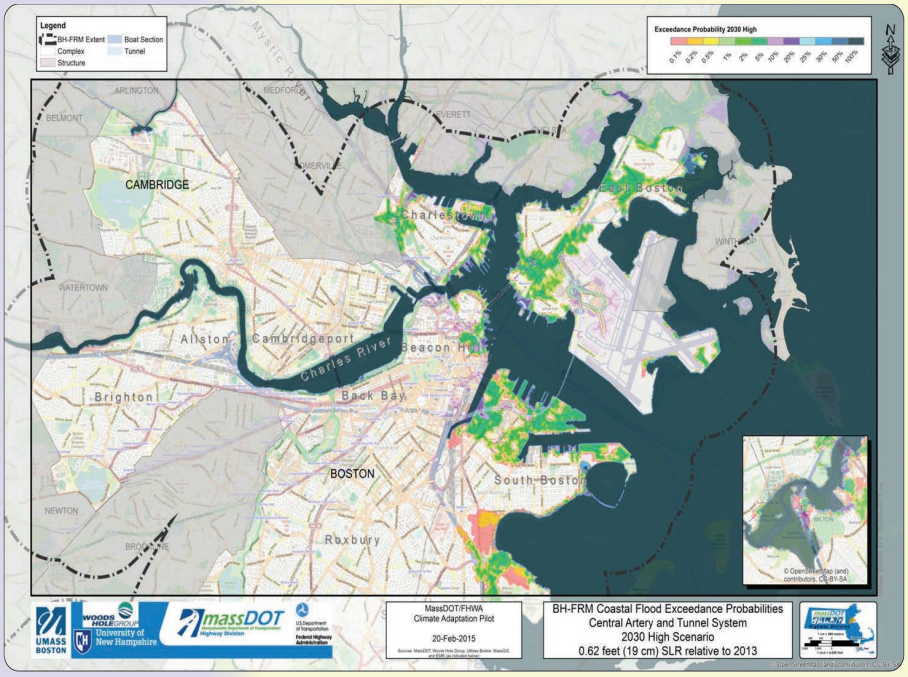
flooding on infrastructure, but it does not include storm surge, wave dynamics, or landform responses.

Although this approach provides a useful way initially to identify areas that might become vulnerable to sea level rise, it cannot represent the dynamic nature of storm events and tide cycles, combined with sea level rise, which can create short-term, high-impact flooding. Adding sea level rise to storm surge, wave dynamics, and tides in a dynamic model can result in higher water levels than those that result from the sum of these variables. For the new assessment, MassDOT wanted to simulate important coastal storm processes and impacts at a more detailed level than the traditional bathtub approach could provide.

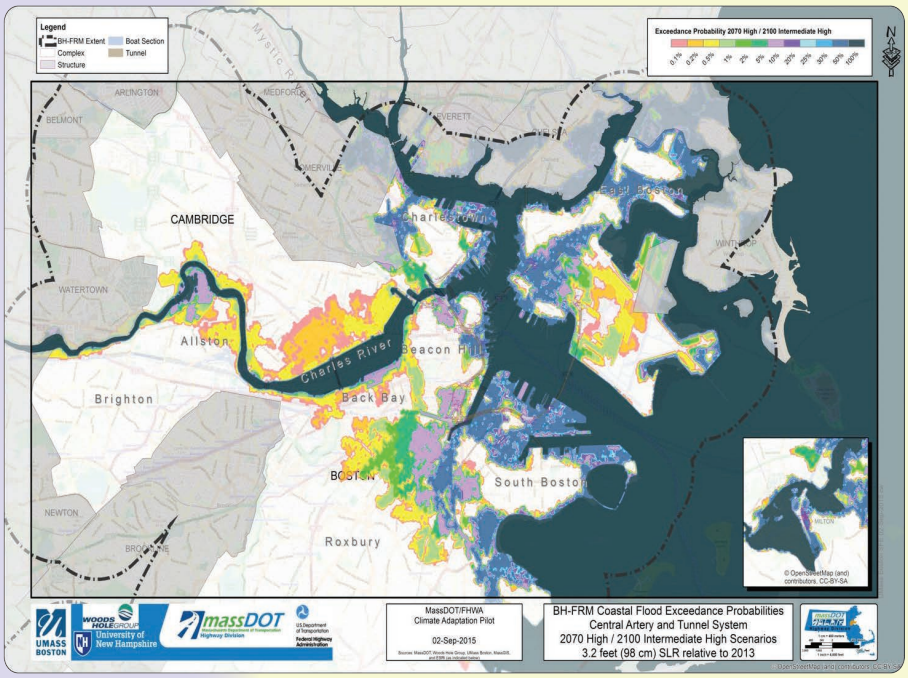
As Kevin Walsh, director of the MassDOT Highway Division's Environmental Services Section, notes, "Because of the importance of the Central Artery/Tunnel infrastructure and its impact on a large population in the heart of Boston, we needed a very sophisticated approach that could capture all of the elements needed to address the complexity of the terrain and bathymetry." (Bathymetry is the measurement of depth at various places in a body of water.)

To identify specific locations that might require adaptations, the MassDOT assessment team used a hydrodynamic model that employs mathematical representations of tides, waves, winds, storm surge, sea level rise, and wave setup—the increase

This large vent building for the Ted Williams Tunnel could be vulnerable to flooding. MassDOT has identified local adaptation options to protect this asset from future flooding. *Photo: MassDOT.*



This map of the Boston area shows the probabilities of exceeding coastal flooding in the Central Artery/Tunnel system in 2030 with 0.62 foot (0.19 meter) of sea level rise relative to 2013. The majority of the flood areas shown range from 2 percent to 5 percent probability of flooding. *Photo: MassDOT.*



This map shows an intermediate scenario of coastal flooding of the Central Artery/Tunnel system in 2070 with 3.2 feet (1 meter) of sea level rise relative to 2013. Included is 2.5 inches (6 centimeters) of land subsidence. The majority of flood areas range from 1 percent to 50 percent probability of flooding with more flood areas around the Charles River than were showing in the previous scenario. *Photo: MassDOT.*

in water level caused by wave runup. The team used the ADvanced CIRCulation (ADCIRC) model to simulate storm formation in the Atlantic Ocean. The team coupled that information with the Simulating WAves Nearshore (SWAN) software to simulate storm-induced waves in concert with the hydrodynamics data. The coupled model, called the Boston Harbor Flood Risk Model, is capable of simulating anticipated coastal storm processes and their potential impacts from storm surge flooding.

To maintain consistency with other local work related to climate change, the assessment team selected four time horizons—2013, 2030, 2070, and 2100—and developed scenarios that simulate the projected sea level rise and impacts of hurricanes and Nor'easters for each of those times. Modeling both types of storms is important because they can cause the same severe impacts but differ in size, geography, and characteristics. The team modeled a statistically robust sample of storms under different climatic circumstances to determine the probability of flooding throughout the Boston Harbor region.

For each of the four time horizons, the assessment team generated maps indicating the risk of flood inundation and showing the associated water depths throughout the Central Artery/Tunnel network. The maps identify locations, structures, and assets that lie within various flood risk levels. The team also used the maps to assess flood entry points and pathways.

Preliminary Results

The MassDOT team defined an asset as exposed if the depth of flooding in the model data exceeded the storm-designed standards that governed the original design. For example, the designers of the Central Artery/Tunnel had established the design standard for tunnel entrances to meet the 1,000-year flood event (that is, the flood elevation that has a 0.1 percent probability of being equaled or exceeded in any given year) plus a minimum wave height of 1.5 feet (0.46 meter). The original planners had designed the tunnel's structures (for example, vent buildings) to the city's building code for the 100-year flood event, including wave action.

The assessment team labeled assets as exposed if the projected flood elevation exceeded these standards. Using the high-resolution flood elevation maps generated for the Central Artery/Tunnel system, the team identified all assets currently exposed

to flooding, as well as those that will be exposed in the future.

The results showed that, under current conditions, the extent of flooding in the Central Artery/Tunnel system is fairly limited. Only a few individual structures are considered vulnerable. As sea levels rise and storm surges increase in future years, the number of assets that will experience flooding, as well as the depth of flooding, will increase. By 2070, the number of vulnerable structures requiring major adaptation will more than triple, compared with the current number.

Next Steps

Using this information about current and future climate-related vulnerabilities, MassDOT is investigating various adaptation options to make the system more resilient to anticipated flooding. First, the agency is looking at local adaptation options to protect individual structures and portals. Local-, structure-, and portal-focused adaptation solutions currently under consideration include temporary flood barriers and a robust program of tide gate repairs and installations for stormwater outfalls (the points where a stormwater system discharges into a body of water).

The agency also is beginning to collaborate with stakeholders regarding regional adaptation options that focus on addressing flood pathways. In contrast to solutions that focus on improving the resiliency of individual structures, regional adaptation solutions focus on addressing flood entry points to protect larger areas from the risk of flooding. The regional solutions under consideration could be more cost effective than the collective local solutions within the same flood path, but the regional approaches will require coordination and investment by multiple stakeholders.

In addition, MassDOT is conducting analyses to identify flood pathways and flood duration timelines to further refine the adaptation options.

Although the assessment team initially developed the Boston Harbor Flood Risk Model to assess the tunnel's vulnerability, the model's usefulness has extended far beyond the initial project. Currently, MassDOT is using the model to develop an assessment examining the impacts of sea level rise and increased tidal and storm surge flooding on Federal and State coastal transportation infrastructure. As part of this study, MassDOT is applying the methods used to develop the Boston Harbor model to create the Massachusetts Coastline Flood Risk Model to account for present and future climate change impacts along the entire coastline of Massachusetts, including the islands of Martha's Vineyard and Nantucket.

MassDOT has also shared the Boston Harbor Flood Risk Model with its State and local partners, including Boston, which is using the model as part of its climate-ready initiative, and Cambridge, which used it to model sea level rise and storm surge scenarios for its vulnerability assessment.

Agency officials are mindful that they will need to redevelop and rerun the Boston Harbor Flood Risk Model within the next 10 years to account for changes in climate conditions and available technology to model storms, coastlines, and city landscapes. Today, MassDOT is therefore focusing on resiliency options for the present and 2030 while keeping 2070 in mind.

Deerfield River Watershed

The Central Artery/Tunnel project is just one of many different activities MassDOT is pursuing in order to understand and address the impacts that climate change may cause on infrastructure. In partnership with the University of Massachusetts Amherst, MassDOT is developing risk-based and data-driven protocols for assessing the present and future flood vulnerability of roadway crossing structures in the Deerfield River watershed, an area that spans 665 square miles (1,722 square kilometers) and 36 towns in northwestern Massachusetts. The project will result in a systems-based approach for improving the assessment, prioritization, planning, protection, and maintenance of roads and road-stream crossings within the watershed. It will also produce a decisionmaking tool for MassDOT to use during project planning and development.

The project has involved extensive data collection, including site visits to nearly 850 road-stream crossings. The research team will analyze each crossing to identify those that are most at risk to a variety of potential climatic stressors and risk factors, including present and future flood conditions, geomorphic responses such as erosion and landslides, and systemwide changes in river morphology. The team will assess the associated potential for disruption of local emergency services. Finally, the researchers will assess transportation-related barriers to aquatic and wildlife continuity, and identify those sites where mitigation of those barriers would do the most good for fish, other aquatic organisms, and wildlife populations.

The project will result in a series of geographic information system (GIS) maps that rank current and future infrastructure vulnerabilities, road-stream crossings based on their potential to restore stream continuity, and potential failures at crossings. Also, MassDOT will create a decision support matrix to prioritize actions that address threats to safety, the transportation network, and the regional ecosystem.

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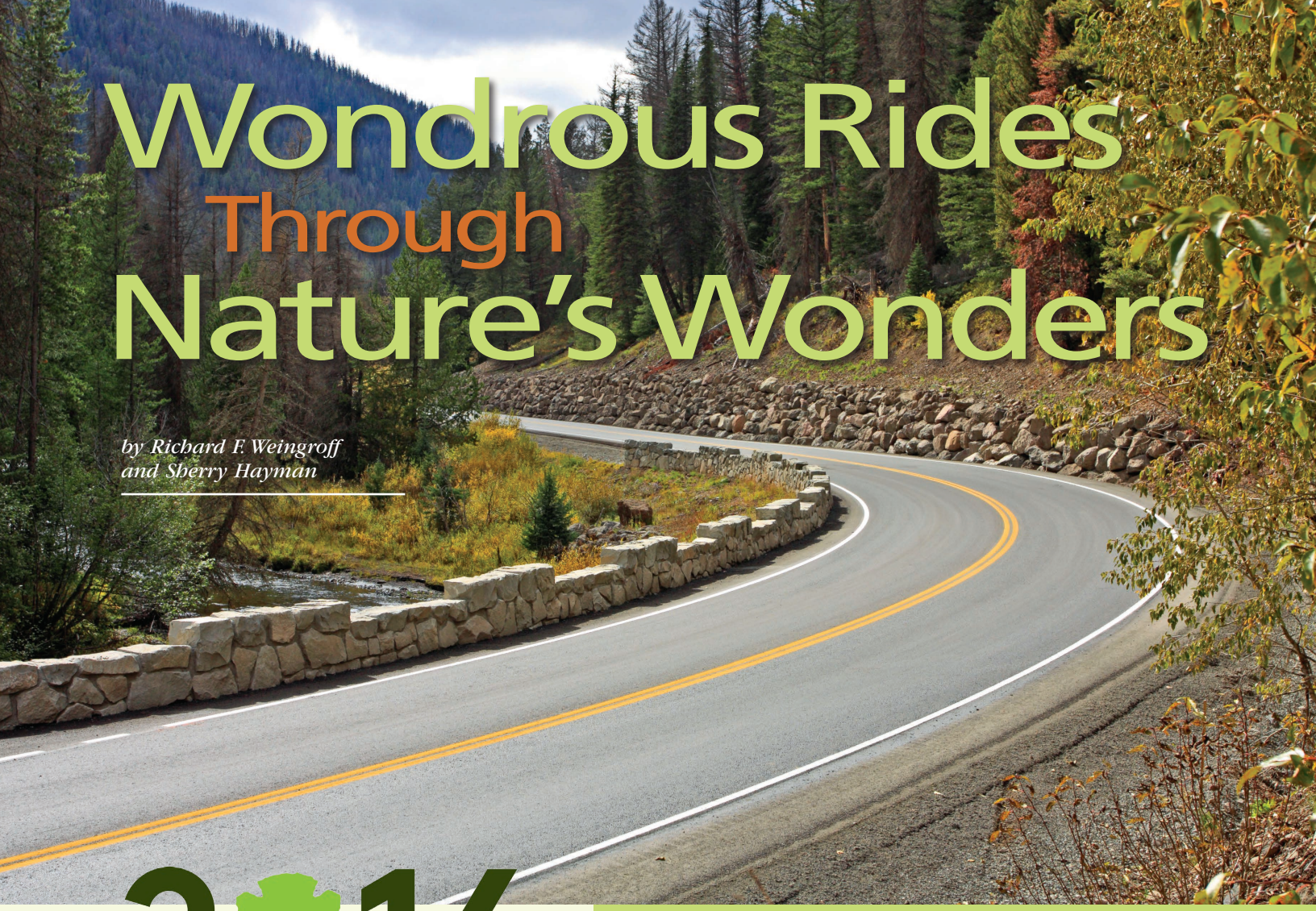
Katherin McArthur is an environmental analyst at MassDOT. She holds a master's degree in environmental management from Yale University and a B.A. in ecology and evolutionary biology from Princeton University.

For more information, see www.massdot.state.ma.us/Portals/8/docs/environmental/SustainabilityEMS/Pilot_Project_Report_MassDOT_FHWA.pdf or contact Steven Miller at 857-368-8809 or steven.j.miller@dot.state.ma.us.

Wondrous Rides Through Nature's Wonders

by Richard F. Weingroff and Sherry Hayman



2016 National Park Service CENTENNIAL

The partnership between the National Park Service, which turns 100 this year, and FHWA has created highway landmarks throughout the country.

On March 1, 1872, President Ulysses S. Grant signed legislation creating Yellowstone National Park as "a public park or pleasuring-ground for the benefit and enjoyment of the people." Yellowstone was the world's first national park. With it was also born the need to travel to and within the designated lands.

(Above) The East Entrance Road in Yellowstone National Park enables visitors to access and enjoy the scenic beauty of the Nation's first national park.

Early in the 19th century, mountain men passed through the hard-to-reach Yellowstone region, which was surrounded by mountains, snowbound much of the year, and so far from civilization that only word-of-mouth reports gave a hint of its beauty. The mysteries began to fall away as a result of expeditions in 1869–1871, some backed by the Northern Pacific Railroad, always eager to expand its passenger business. In 1870, a Montana-based expedition named many of the future park's features, including the geyser known as Old Faithful.

An 1871 expedition headed by Ferdinand V. Hayden, chief of the U.S. Geological Survey of the Territories, included an artist and photographer, whose images helped Americans see the valley's wonders. With Hayden's support and strong promotion by Northern Pacific Railroad publicist Nathaniel P. Langford, who went on the 1870 expedition, the bill creating the national park attracted a number of advocates. To show the need, the bill's supporters pointed to Niagara Falls as an infamous example of what happens when entrepreneurs fill the vacuum of public indifference

to majestic public lands. As *National Geographic* magazine put it recently, "private operators there had bought up the overlooks and blocked the views, turning that spectacle into a commercial peep show."

In 1872, *The New York Times* predicted that, in a few years, people from Europe—then the popular vacation spot for well-off Americans—would visit the park "to drink the waters, and gaze on picturesque splendors only to be seen in the heart of the American Continent."

By late August 1916, the country had 15 national parks. In addition, protected public land included national monuments administered by the U.S. Department of the Interior (historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest on land owned by the Federal Government), bird reserves administered by the U.S. Department of Agriculture's Biological Survey to protect native wild birds, and land overseen by the U.S. Forest Service.

To Auto or Not

For several decades, people had only one travel option for visiting national parks: railroads. Within the parks, horses were the primary means of transporting visitors, either on horseback or in carriages and stagecoaches.

Early in the 20th century, motorists and automobile clubs put pressure on the national parks for vehicle access. As Timothy Davis, National Park Service (NPS) historian, put it in his 2016 book *National Park Roads: A Legacy in the American Landscape*, "The automobile was greeted with a mixture of enthusiasm and apprehension when it clanked and wheezed its way into national parks at the turn of the 20th century."

Park officials questioned the idea. As Major Harry Benson, superintendent of Yellowstone National Park, put it in a 1909 letter to the Secretary of the Interior, road conditions and the nature of the country would "render the use of automobiles not only inadvisable and dangerous, but to my mind it would be practically criminal to permit their use." Benson also feared that noisy automobiles would spook the thousands of horses working in the park.

The Interior Department gradually allowed automobiles into parks subject to detailed regulations. In general, the early regulations required the park superintendent's written permission to enter and permitted automobile use during limited hours to reduce conflicts with horses. Automobiles were required to pull over and stop to let horse-drawn vehicles pass. The speed limit was 6 miles per hour (9.6 kilometers per hour), but on straight stretches, motorists could accelerate to 15 miles per hour (24.1 kilometers per hour) if no teams were in sight.

Regulations aside, the condition of the roads was a restraint on automobile use. Secretary of the Interior Walter L. Fisher said in 1912 that "in the main, the roads that are constructed are entirely unsuitable for automobiles, especially if they are to be combined in any way with horse travel." The roads were "narrow, curves are all over the parks, and comparatively little progress has been made in the construction of roads that were originally made for a large, heavy, lumbering coach, drawn by two to six horses."

After President Woodrow Wilson took office in March 1913, his Secretary of the Interior, Franklin K. Lane, was more open to automobile use in the parks. When Secretary Lane's assistant, a millionaire economist and professor named Adolph C. Miller, was diverted to work on plans for the Federal Reserve, President Wilson advised the Secretary to "find another millionaire with an itch for public service."

That millionaire turned out to be an acquaintance of Lane's, Stephen T. Mather of Chicago, IL, a one-time journalist in New York City who had become a millionaire from the mining, manufacture, and sale of borax. Mather was a member of the Sierra Club and the American Automobile Association (AAA) as well as a conservationist who enjoyed touring the western parks and forests. When he wrote to criticize administration of the national parks, Secretary Lane replied, "Dear Steve, If you don't like the way the national parks are being run, come on down to Washington and run them yourself." Mather, 47 years old, took the oath of office as assistant to the Secretary, a post that paid the millionaire $2,750 a year.

One of the many tasks Secretary Lane assigned to his new assistant was to study whether to let automobiles into Yellowstone. Mather established a committee that developed a road-use schedule to keep automobiles and horses separated to the extent possible. Automobiles entered Yellowstone in August 1915. As for horses, an NPS history explained, "The stagecoach companies quickly adapted to the situation, chauffeuring visitors around the parks in gaily colored touring cars."

An account of the 1870 exploration of the Yellowstone Valley in *Scribner's Monthly* included this sketch of the Geyser Basin (now known as the Upper Geyser Basin), including what the expedition named Old Faithful. *Source:* Scribner's Monthly, *June 1871.*

In the NPS annual report for fiscal year 1917, Director Stephen Mather described how "the entire concession system has been reorganized; large 10-passenger automobiles, especially adapted to the requirements of tourist travel have superseded the ancient stagecoaches" during the tourist season "without inconveniencing the public or interfering with its pleasure in any way." He illustrated the change with this photograph, here converted to a postcard, showing the auto stages on Chittenden Bridge in Yellowstone. *Photo: J. E. Haynes, used by permission of the Montana Historical Society.*

Roads in National Parks And National Forests

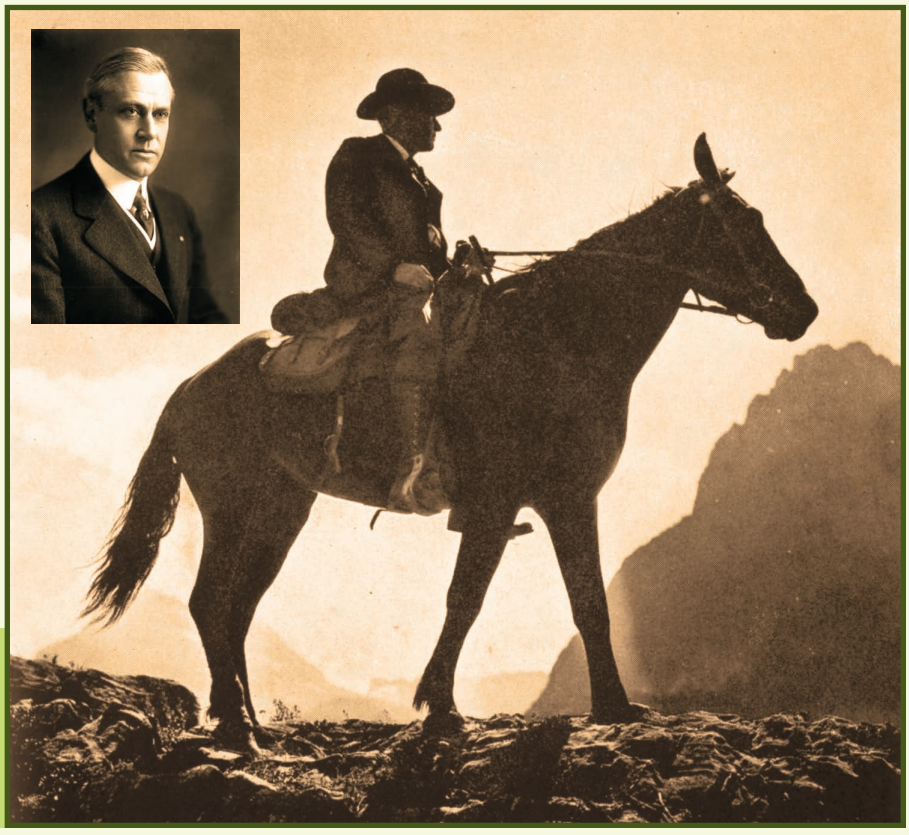
National forests had an advantage over national parks. They had a source of revenue from timber harvesting, livestock grazing, and other commercial activities.

With the formation of the U.S. Forest Service (USFS) in 1905, the Department of Agriculture advised its new agency to work with the department's U.S. Office of Public Roads (OPR) to explore forest road needs. Initially, OPR's contribution was mainly advisory. However, in 1912, Congress began setting aside 10 percent of revenue from commercial activity in the national forests for the construction and maintenance of roads and trails within the forests. This provision, the first law providing a sustained source of revenue for roads in the public domain, generated $210,925 in fiscal year 1912 and $239,192 in 1913.

By contrast, the legislation authorizing national parks prohibited extraction of natural resources. The U.S. Army Corps of Engineers (USACE) performed most of the road construction in the parks, but the work was subject to funding from an often stingy Congress and the occasional philanthropy of private organizations and individuals. By the 1910s, the Interior Department began calling on OPR to help with road surveys.

On February 16, 1914, OPR Director Logan W. Page created the Division of National Park and Forest Roads, with T. Warren Allen as chief. Most work in the parks that first year involved surveys and plans, not construction. Allen placed an engineer in Yosemite and made plans for an engineer in Glacier National Park, survey parties in General Grant (now Kings Canyon) and Sequoia National Parks, and inspection of road conditions in Mount Rainier and Wind Cave National Parks.

Allen believed that the parks would not achieve their best use unless roads provided access to entrances and to primary points of interest. In 1915, he told a national parks conference, "I, as a road builder, have dreamed of road



NPS Director Mather, shown here in Glacier National Park, enjoyed traveling the parks on horseback. (Inset) Director Mather in 1916. *Photos: National Park Service.*

development in the various parks." However, Allen understood the difficulty of construction where roads would have to provide access without interfering with the parks' natural wonders. For the roads, he emphasized, "No pains should be spared."

In 1916, Allen reported that, "very little work has been done in the national parks." He had inspected road conditions in Rocky Mountain. In addition, the division was surveying the Lake McDonald-East Shore Line Road, the Lake McDonald-West Shore Line Road, and the Fish Creek-McGee Meadow Road in Glacier. The division had completed plans for the El Portal Road in Yosemite.

The Push for a Bureau

President Theodore Roosevelt, an outdoorsman and conservationist, held a Conservation Conference of Governors in 1908. The conference focused mainly on national forests, but in one of the few references to the national parks, businessman J. Horace McFarland called them "one of America's greatest resources" and said they "ought to be absolutely inviolate."

McFarland, who ran a printing business in Pennsylvania, decided that the national parks should be run by a single government bureau, similar to the USFS. He devoted his civic improvement group, the American Civic Association, to the cause. (He called the association "a militant organization for the national good, free from red tape and ready to jump.")

At McFarland's urging, Interior Secretary Richard A. Ballinger included a call in his 1910 annual report for creation of a Bureau of National Parks and Resorts. The importance of the national parks, the Secretary wrote, "has passed beyond the stage of satisfactory control by operations carried on with the small force available in the Secretary's office."

On December 13, 1911, McFarland's association held its annual conference in Washington, DC. President William Howard Taft's address to the association supported a bureau. The United States managed its "great many natural wonders" in a "lazy way." Because the lands are government property forever, the attitude was, "we will wait in our own good time to make them useful as parks to the people of the country." To illustrate, he said a visitor to Yellowstone might admire the ability of the engineers who designed "such roads as are there," then travel to Yosemite where he would find "the roads not quite so good."

Working the Parks: Recollections of the Early Days

In 1976, FHWA published *The Trailblazers*, containing employee recollections of early work in the national parks and national forests. The full collection is available at www.fhwa.dot.gov/infrastructure/blazertoc.cfm. The following are excerpts.

Bryce Canyon National Park: Karl S. Chamberlain

The field party [in 1923] was made up of a resident engineer and one other instrument man who were regular employees. The balance of the crew were temporary employees, most of whom were students. According to my recollection, expenses were paid to a limit of $1.20 per day. The automotive equipment consisted of World War I surplus equipment. The resident engineer rated a car, and another was provided for the crew. Both were Model T Fords of the crank-up variety for starting. They used high-pressure tires, and it was an uncommon day's travel if there was not at least one flat tire—repaired and patched on the spot.

The quarters and field offices on the project consisted of tents without the benefit of floors or other unnecessary luxuries. The furnishings in the sleeping tents were rough lumber bunks without mattresses. Fresh-cut pine boughs served as a substitute. A water bucket on a rough lumber stand and a wash basin completed the furnishings. Meals were taken at the contractor's mess at a cost of $1.00 per day. Food was plentiful, but the mess tent was unscreened. A large horse tent was located in the vicinity as nearly all motive power for the construction was horse-drawn.

Living conditions were rather primitive. A Saturday night bath could be taken in a round tub with only warm water heated on a small wood stove. On a Saturday night, a trip to town could provide a good bath at the barber shop for 25 cents. A cafe meal could also be bought for the very low price of 35 cents plus.

Crater Lake National Park: Norman Wood

During the summer season of 1931, someone decided that part of the Rim Road around Crater Lake should be located inside the crater itself. . . . As was then customary on location surveys, the party chief (me) was out in front of the transit party "flagging the line." Along the base of the vertical cliff above me was a narrow game trail, and it was along this trail we proposed to run the "P" line. About the middle of the afternoon, of the first day out, I was setting an angle flag along this trail at a point in a small draw along which I could look downward some 800 feet [243 meters] and see the deep blue water of the lake. As I attempted to drive the lath, I apparently shifted my weight and my footing gave way. Down I went—with my axe and bundle of lath. While the lath and axe were never found, I managed during my slide down about a 1:1 slope to catch hold of a large rock imbedded in the slope and stop my slide before I reached the vertical drop below me. I "froze" and was unable to move for a time, after which I dug my boot toes into the pumice slope and transferred some of my weight away from my arms. . . . This is the closest I have yet come to going to the big survey camp in the sky—needless to say, I never again worked in such areas alone or without ropes. I cannot yet look over a high cliff without the same cold fear I experienced that day.

Mount Rainier National Park: Rene Wright

Animals were an occasional nuisance around camps [in the 1920s], especially the big, black bears in [Mount] Rainier National Park. One big fellow would come around the cook tent every day for scraps or whatever else he could find to eat—he knew exactly what time dinner was served. We tried to scare him off with boiling water, sharp sticks, pepper, and everything else, but to no avail. The Park Service finally trapped him in a big corrugated pipe trap and hauled him off to the other end of the park. In three days, however, he was back.

Cougars would follow you around to see what you were doing. They would follow you directly in your trail, criss-crossing to stay out of sight. They didn't pose a problem unless you wounded one. Most of the so-called "wild" animals weren't aggressive—they didn't seem to consider us enemies.

Landowners were another occasional problem, although most were extremely cooperative. A few would object if you went through the middle of a field. Survey parties were sometimes challenged with shotguns and a local sheriff would have to be called out to control the owner.

Yosemite National Park: Eric E. Erhart

In the spring of 1926, Tom Roach hired on in Yosemite Park as transit man for Harry Tolan. . . . Tom was later in charge of driving the Wawona tunnel in Yosemite. One of his favorite stories is telling how they had cut a window in the tunnel wall to outside air. This permitted the tunnel air to exhaust immediately after each successive blast permitting the crew to start working sooner. On one occasion Tom thought about standing in one of the windows when a shot was fired. On second thought he set a loaded wheelbarrow in the window. When the shot went off, the wheelbarrow was blown into oblivion in the next canyon.

In the 1910s, most people traveled to the national parks by railroad. This 1916 map depicts the national parks and the railroads providing access to them. *Source: National Park Service.*

President Taft acknowledged that the idea of a new agency might raise the "gooseflesh" of budget officials and some members of Congress, but if the country was going to have national parks, "we ought to make them available to the people, and we ought to build the roads, expensive as they may be, in order that those parks may become what they are intended to be when Congress creates them." A bureau might increase costs, "but it is essential that we should use what the Lord has given us in this way, and make it available for all the people." It would not "exhaust the Treasury" and was "a necessary expense. Let us have the bureau."

Interior Secretary Fisher followed the President's address at the conference by discussing the absence of consistent legislative authority over the parks. At that time, some parks had statutory authority to use the revenues generated in the park for improvements. Others did not. The funding Congress authorized varied for each park based on "political pressure." The result was "that we have no consistent theory of park administration." A Bureau of National Parks would "vastly improve their condition and their advantage to the public." (The phrase "and Resorts" was dropped from the name because it implied an appeal to the wealthy.)

On February 2, 1912, President Taft submitted a special message to Congress about the Interior Department. The message covered many topics, including establishing a Bureau of National Parks. He said: "I earnestly recommend the establishment of a Bureau of National Parks. Such legislation is essential to the proper management of those wondrous manifestations of nature, so startling and so beautiful that everyone recognizes the obligations of the Government to preserve them for the edification and recreation of the people."

Only at Yellowstone had the country "made anything like adequate preparation for the use of a park by the public." He concluded: "Every consideration of patriotism and the love of nature and of beauty and of art requires us to expend money enough to bring all these natural wonders within easy reach of our people. The first step in that direction is the establishment of a responsible bureau, which shall take upon itself the burden of supervising the parks and of making recommendations as to the best method of improving their accessibility and usefulness."

Although legislators had introduced bills to create a bureau as early as December 1911, President Taft's support gave the idea renewed energy. Representative John E. Raker, a member of the Committee on the Public Lands whose California district included Yosemite, introduced a bill to create the National Park Service. Senator Reed Smoot of Utah, chairman of the Senate Committee on Public Lands, introduced a bill to create a Bureau of National Parks. However, neither bill made it out of committee.

Conditions Shift

In 1912, the Republican, President Taft, lost his reelection bid to the Democrat, New Jersey Governor Woodrow Wilson, who came in first, and to former President Roosevelt, who came in second running on a third-party Progressive (Bull Moose) ticket.

Senator Smoot and Representative Raker again introduced legislation in April 1913. Both bills called for a National Park Service with a director who would have "the supervision, management, and control" of the national parks and other national monuments and reservations. The bills were still in committee when the 63rd Congress ended on March 3, 1915.

By the time the 64th Congress convened on December 6, 1915, the situation had changed.

The Panama-Pacific International Exposition in San Francisco, CA, and the Panama-California Exposition in San Diego, CA, that opened in 1915 attracted millions of visitors. The expectation that many of these visitors would travel by automobile was one of the reasons vehicles were allowed into Yellowstone. Many travelers stopped off at one or more national parks before or after they reached the expositions. Members of Congress also visited the parks, heard from constituents who had visited them, or read newspaper and magazine accounts of the parks' wonders.

Most travelers used railroads for interstate travel, but long-distance automobile touring was growing. The automobile, formerly accessible only to the wealthy, became popularly available once Henry Ford introduced the low-priced Model T in 1908. After that, private groups identified interstate roads, gave them

colorful names, and aggressively promoted their improvement and use. In 1915, the named roads with termini on or near the west coast promoted their routes as the best access to the expositions. Some trail associations used the national parks in their names, such as the National Parks Highway (the route from Chicago, IL, to Crater Lake National Park passed Yellowstone, Glacier, and Mount Rainier), the Yellowstone-Glacier Bee Line Highway, and the Yellowstone Trail (which had the motto "A Good Road from Plymouth Rock to Puget Sound" and linked Yellowstone, Glacier, and Mount Rainier). There was also the Yellowstone-Yosemite Highway, and the National Park-to-Park Highway, a 6,000-mile (9,656-kilometer) loop linking the western parks, with the motto You Sing "America"—Why Not See It?

Further, the outbreak of World War I in Europe in August 1914 cut off the European tours that had been common among those who could afford them. As a result, the See America First movement that had begun in the early 20th century gained strength. As historian Marguerite S. Shaffer explained in her 2001 book about the movement, "The Panama-Pacific International Exposition succeeded in some ways where earlier campaigns had failed because of widespread corporate support combined with the rise of reactionary patriotism sparked by the European war."

During the American Civic Association's annual conference in December 1915, speakers promoted the national parks under the See America First theme. Gilbert H. Grosvenor, director of the National Geographic Society, told the conference, "Americans should go to see their own parks. They are better than anything in Switzerland." Europe had better accommodations, but if Americans would instead spend their tourist millions "in America for a while there would be equal accommodations here to go with the far superior and less spoiled scenery."

At the same time, with encouragement from Mather, the railroad companies were heavily promoting the great parks. The Atchison, Topeka & Santa Fe Railway and Union Pacific Railroad invested about $500,000 to provide exhibits on the national parks at the 1915 expositions. In 1916, the railroad companies issued 2 million copies of promotional literature on the parks to encourage ticket sales.

Also in 1916, 17 companies pooled $43,000 and Mather personally contributed $5,000 for the first edition of *National Parks Portfolio*, a deluxe collection of park photographs designed to appeal to the wealthy and influential travelers looking for an alternative to war-torn Europe. (NPS published later editions, but instead of giving them away as with the first edition, charged $1. Even so, it became one of the agency's all-time bestsellers.)

National Park Service

With these forces at play, Mather decided the time for action had come. He joined with McFarland, Grosvenor, Representative Raker, Frederick Law Olmsted, Jr., Representative William Kent, and others to lay out the strategy. For one thing, they agreed that Representative Raker would take a back seat. He was in a feud with House Minority Leader James R. Mann that could undermine the

In 1915, Stephen Mather encouraged supporters who wanted to develop a highway loop, dubbed the National Park-to-Park Highway, linking the national parks in the western part of the country.

bill. Instead, Representative Kent, a conservationist who represented a district in Marin County, CA, would take the lead in the House. He introduced his bill in January 1916.

By the time the bill reached the House floor, prospects for passage in a presidential election year were uncertain, but as it turned out, concerns were about details, not the general idea. Representative Irvine L. Lenroot, a self-appointed treasury watchdog from Wisconsin who had often fought against spending on the parks, forced a change in the bill to limit the number of employees in the service. He also proposed a successful amendment to reduce the director's annual salary from $5,000 to $4,500. Other concerns involved grazing rights, control of monuments, and why the NPS director needed an assistant at a salary of $2,500. Nevertheless, after a brief debate, the House passed the Kent bill without a recorded vote.

Senator Smoot had introduced the NPS bill in the Senate, where it came up for a vote on August 5. Senator Jacob H. Gallinger of New Hampshire was the only critic. He was concerned that the new service would turn into "another great bureau . . . as large a bureau as the Forestry Service." Although serving a gadfly function during the debate, he said he would honor Senate courtesy that dictated that Senators from the East would not interfere in western affairs. The bill passed the Senate, again without a recorded vote.

After a House-Senate conference resolved differences between the bills, the Senate approved the bill on August 15 and the House did so August 22, without debate in both cases.

With Mather due to return from a long trip through western park country on August 28, his assistant, Horace M. Albright, wanted a telegram waiting for him with the news that the bill was law. The problem was that President Wilson was not planning to sign that bill and others before Mather's return. By chance hearing that the President might make an exception, Albright persuaded a legislative clerk at the White House to send in the park bill. Rushing out of the room, Albright added, "Oh, and save the pen he signs it with for me, will you?" President Wilson signed the bill that evening without ceremony or a photograph. Albright dispatched the telegram to Mather and received the pen for the new agency.

The National Park Service Organic Act created the NPS under charge of a director who would have an assistant, a chief clerk, a draftsman, a messenger, and "such other employees as the Secretary of the Interior shall deem necessary," as long as the total salaries did not exceed $8,100.

The law described the new agency's mission in words that Olmstead had written for the Kent bill: "The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

The legislation left unanswered how to provide for enjoyment of the parks without impairing the natural environment for future generations.

The Secretary was authorized to cut timber "to control the attacks of insects or diseases or otherwise conserve the scenery or the natural

In 1926, Chief Thomas H. MacDonald of the U.S. Bureau of Public Roads, shown here, joined NPS Director Mather in signing a memorandum of agreement "Relating to the Survey, Construction, and Improvement of Roads and Trails in the National Parks and National Monuments." The agreement, updated over the years, has been providing access to America's treasures ever since.

In Glacier National Park, engineers and crews building the Transmountain Highway (renamed the Going-to-the-Sun Road) confronted rugged conditions. This photograph from October 1925 shows two crew members standing on rocky terrain.

Stone masons working on the Transmountain Highway in Glacier National Park lived in tents like this one while building the retaining wall.

About 2,000 people attended the dedication ceremony for the $1.9 million, 25-mile (40-kilometer) Zion-Mt. Carmel Highway in Zion National Park in Utah on July 4, 1930. The ceremony took place in this gallery of the 1.1-mile (1.8-kilometer)-long tunnel that is a unique feature of the highway. Guests included the Governors, NPS Director Horace M. Albright, and Chief Thomas H. MacDonald of the Bureau of Public Roads. During the ceremony, Utah Governor George H. Dern said, "Perhaps the most remarkable part of the work is the engineering, and I take off my hat to the men who conceived this almost impossible project and carried it through to a successful conclusion." *Photo: American Association of State Highway and Transportation Officials.*

or historic objects in any such park, monument, or reservation." He may "grant privileges, leases, and permits" for accommodation of visitors, but "no natural curiosities, wonders, or objects of interest shall be leased, rented, or granted . . . to interfere with free access to them by the public." The Secretary also was to issue regulations covering grazing of livestock.

Interior Department officials established the National Park Service immediately after legislation was enacted on April 17, 1917, making funds available for that purpose. Mather, having secured the agency he had come to Washington to create, was about to wind up his public service. Instead, on May 16, 1917, he became NPS director, a post he would hold until he suffered a paralyzing stroke that led to his retirement on January 8, 1929.

By 1917, the need for the USACE in the national parks had diminished. As Robert Shankland's biography of Mather put it, "There were no more insurrections to put down." Further, the Secretary of War objected to the continued use of military funds for park work. The Interior Department began replacing the soldiers with rangers, a change that was completed when the last Army engineer left Crater Lake in 1919.

Making the Parks Available

The problem, Mather said in a 1915 interview, "consists chiefly in making these national playgrounds available and useful to the people. Means of getting to them and living in them economically when one gets there must be systematized better than they have been."

Railroad companies had promoted travel to the parks aggressively for years, but Mather was well aware of the growing importance of the automobile to the national parks and other NPS facilities. The question was what type of roads would best serve the parks—and how to pay for them.

The 1916 Organic Act had not included a funding mechanism, leaving the NPS subject to the annual will of Congress. As of 1924, Congress had appropriated a total of $3.5 million for park roads over the half-century of national parks, or an average of less than $70,000 a year. By then, the parks had 1,060 miles (1,706 kilometers) of roads, most of which were better suited to horses than automobiles.

Mather, in 1917, borrowed George E. Goodwin from the USACE and made him chief engineer, a post he held until 1925. Goodwin was a skilled road builder, but his work was criticized because, while working within NPS budget realities, he often defied the NPS policy of reducing the visibility of roads.

During this period, the NPS neglected its brief partnership with the Bureau of Public Roads (BPR), as OPR would be called beginning in 1918. Moreover, the Federal-Aid Road Act of 1916, which created the Federal-Aid Highway Program, also had authorized $1 million per year for 10 years for forest roads, trails, and bridges. As work with the NPS declined, BPR eliminated its parks and forests division and focused on the expanded forest work.

The Transmountain Highway in Glacier brought the two agencies together again. Goodwin had completed an early design for it in 1918 and had begun construction. By 1924, Mather decided the plan included too many switchbacks (a zig-zag pattern to ascend a steep grade) approaching Logan Pass. Mather turned to BPR Chief Thomas H. MacDonald for help in conducting a survey of the link. MacDonald was pleased to show what his agency could do.

BPR's Frank Kittredge directed the survey that mapped 21 miles (34 kilometers) over the Continental Divide, as his team raced to complete the work before winter closed

NPS describes the Zion-Mt. Carmel Highway as a "road designed to go where no road had gone before." This historic photograph shows the view looking east from Gallery #2. *Photo: AASHTO.*

Skyline Drive, shown here, spans the full length of Shenandoah National Park along the crest of the Appalachian Mountains. The roadway offers physical and scenic access, providing views over the western valley and eastern plateau some 2,500 to 3,500 feet (762 to 1,067 meters) below. *Photo: National Park Service.*

The Bureau of Public Roads, separate from the NPS, completed the Mount Vernon Memorial Highway in Virginia, shown in this 1932 photograph, to parkway standards in 1932. The highway was later incorporated into the George Washington Memorial Parkway, which NPS and BPR collaborated on under their interagency agreement.

in. An NPS historical account states: "Kittredge and his team of 32 men often climbed 3,000 feet [914 meters] each morning to get to survey sites. The crew walked along narrow ledges and hung over cliffs by ropes to take many of the measurements. The work was too challenging for some, and Kittredge's crew suffered from a 300-percent labor turnover in the 3 months of the survey."

The two agencies collaborated on the survey and design, with the NPS having final say and approving construction. Contractors, under BPR supervision, completed the construction, which spanned 2 decades and cost more than $2 million. During the dedication ceremony on July 15, 1933, the Transmountain Highway received a new name: the Going-to-the-Sun Road.

On April 9, 1924, President Calvin Coolidge signed legislation authorizing $7.5 million for the NPS to use over 3 years "to construct, reconstruct, and improve roads and trails, inclusive of necessary bridges, in the national parks and monuments." With one stroke of the President's pen, the NPS had twice as much funding for park roads as had been appropriated in the entire history of the national parks. And in 1928, Congress appropriated another $2.5 million.

Impressed by BPR's collaboration on the Transmountain Highway, Mather decided to use BPR as the park road-building unit, thereby sidelining the NPS engineering division. He and MacDonald approved a formal agreement, completed February 10, 1926, related to the survey, design, construction, and improvement of roads and trails. The NPS would initiate projects, but BPR would conduct surveys in cooperation with NPS landscape engineers, who issued stringent guidelines for landscape preservation and retained ultimate authority over all decisions. Based on the surveys, the NPS would undertake minor projects, but for major projects, BPR would cooperate with the landscape engineers to design the project and administer the resulting contracts. The agencies agreed to "use every effort" to harmonize construction standards on parks and monuments with the standards adopted for the Federal-Aid Highway Program.

This agreement, updated over the years, still governs the interagency collaboration of the two agencies.

Excavation work on the Blue Ridge Parkway, shown here, included a crew drilling holes for explosives used to break up rock, while a diesel-powered shovel loaded earth into dump trucks.

Expanding the Partnership

In addition to rebuilding Yellowstone's road network to automobile standards, the NPS-BPR partnership resulted in several early park road gems such as:

- Zion-Mount Carmel Highway in Zion National Park in Utah
- Desert View Drive approach road to the Grand Canyon in Arizona
- Rim Drive in Crater Lake National Park in Oregon
- The 4,200-foot (1,280-meter) Wawona Tunnel and Big Oak Flat Road in Yosemite in California
- Trail Ridge Road in Rocky Mountain in Colorado
- Tioga Pass Road approach to Yosemite

After Congress designated national parks in the East, one of BPR's eastern projects was Skyline Drive in Shenandoah National Park, designated in 1935 along the Blue Ridge Mountains in Virginia. Work

began in 1931 as a source of employment early in the Depression. Completed in 1939, Skyline Drive was the only road in the park.

In 1928, Congress authorized funds for BPR to build a highway in Virginia between George Washington's Mount Vernon home and Arlington Memorial Bridge, which was planned to connect the Lincoln Memorial in the District of Columbia with Arlington National Cemetery in Virginia. The goal was to complete the highway as part of the celebration of the bicentennial of Washington's birth in 1732.

On January 16, 1932, President Herbert Hoover participated in ceremonies marking completion of the bridge and the BPR's Mount Vernon Memorial Highway. The highway combined freeway design features with a park setting to create what was essentially a long, narrow park.

As BPR worked on the parkway, Congress passed legislation extending it along the Potomac River to Great Falls in Virginia and creating a parallel parkway in Maryland, both to be known as the George Washington Memorial Parkway (the portion in Maryland is now called the Clara Barton Parkway).

The success of Skyline Drive led to consideration of a link between Shenandoah and Great Smoky Mountains National Park (established in 1934). The result was the 469-mile (755-kilometer)-long Blue Ridge Parkway following the crest of the Appalachian Mountains. The award winning Linn Cove Viaduct around Grandfather Mountain in North Carolina, completed in 1987, was the final section to open.

Other projects included the Natchez Trace Parkway in Alabama, Mississippi, and Tennessee; the Colonial Parkway (completed in 1957) in Virginia; and the Baltimore-Washington Parkway (completed in 1954) in Maryland. (For more information on the Natchez Trace Parkway, see "The Road Is a Park, and the Park Is a Road," on page 28 in this issue of PUBLIC ROADS.)

The Blue Ridge Parkway provides beautiful vistas, as in this section near Grandfather Mountain in North Carolina.

The Partnership Continues

At the time of the NPS Organic Act of 1916, the NPS administered 15 national parks that received a total of 356,097 visits. Today, the NPS administers 412 areas, including 59 national parks, plus monuments, battlefields, military parks, historical parks, historic sites, lakeshores, recreation areas, scenic rivers and trails, and the White House. These national assets are located in every State, the District of Columbia, American Samoa, Guam, Puerto Rico, and the Virgin Islands.

In 2015, NPS sites received more than 307 million recreation visits, including 75 million visits to national parks.

NPS facilities of all types cover 5,500 miles (8,851 kilometers) of paved roads, including 1,100 miles (1,770 kilometers) of parkways; 7,000 miles (11,265 kilometers) of unpaved roads; and 17,872 miles (28,762 kilometers) of bicycle and pedestrian trails, of which 5,012 miles (8,066 kilometers) are front country paved trails. The NPS estimates vehicle miles traveled in the national parks to be in excess of 2.4 billion (3.9 billion kilometers).

Today, Stephen Mather and Thomas H. MacDonald are legendary figures in their fields, although little known to the public. However, the partnership they forged in 1926 remains strong today, as FHWA's Office of Federal Lands Highway and the NPS work together to keep the national parks' transportation facilities robust.

As the NPS celebrates its centennial, FHWA is proud of its enduring partnership to expand access to the country's "wondrous manifestations of nature."

In 2007, FHWA and the NPS began a multiyear rehabilitation of the Going-to-the-Sun Road. As shown here, the project included placing stone masonry veneer along a concrete retaining wall to simulate the original masonry construction. The simulated material matches the historic character of the rock wall while adding the stability needed to meet today's safety standards.

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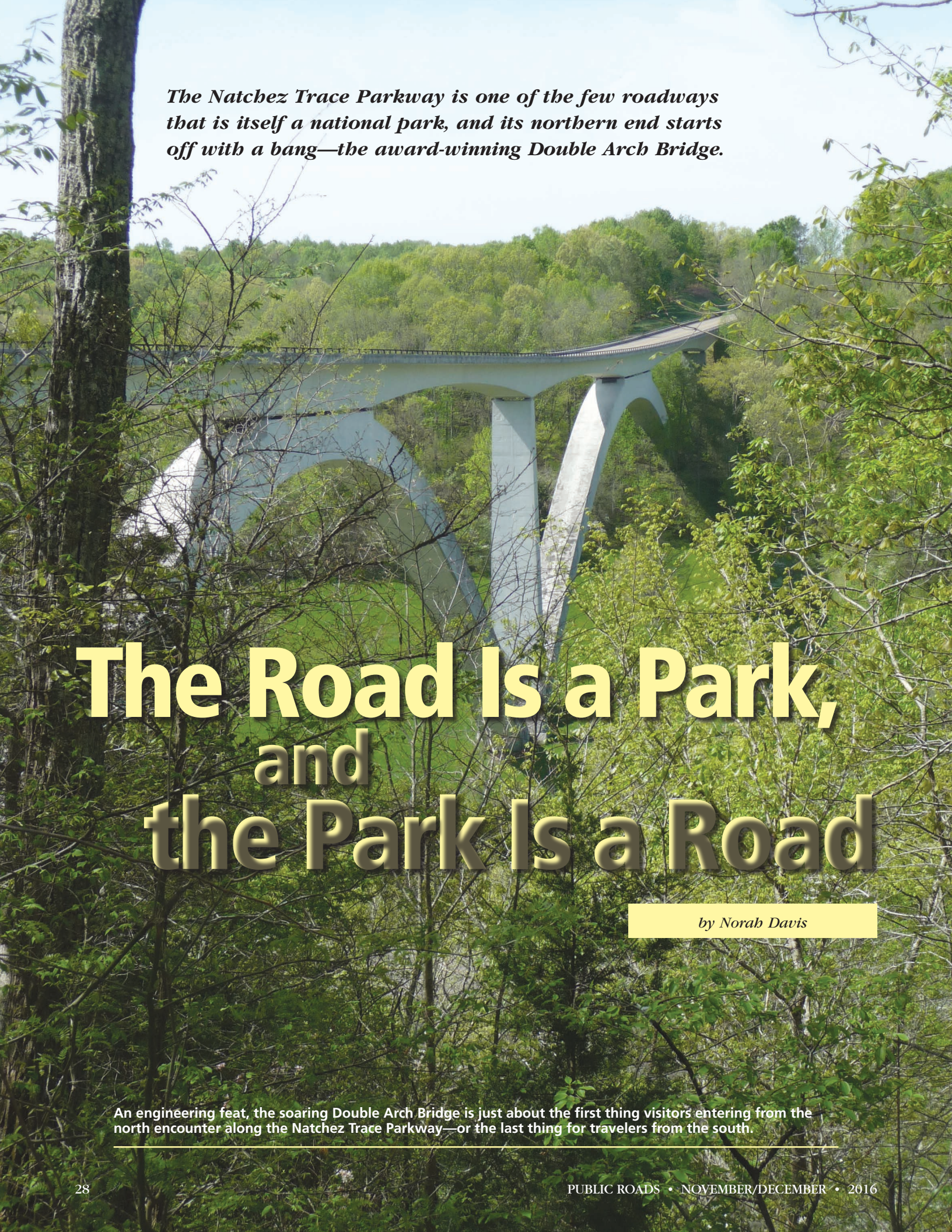
For more information, see the NPS History eLibrary at http://npshistory.com and Historic Roads in the National Park System *by Laura E. Soulliére at www.nps.gov/parkhistory/online_books/roads/index.htm.*

The Natchez Trace Parkway is one of the few roadways that is itself a national park, and its northern end starts off with a bang—the award-winning Double Arch Bridge.

The Road Is a Park, and the Park Is a Road

by Norah Davis



An engineering feat, the soaring Double Arch Bridge is just about the first thing visitors entering from the north encounter along the Natchez Trace Parkway—or the last thing for travelers from the south.

All national parks include roads that run through them, but only a few parks are themselves roads. The Natchez Trace Parkway is less well known than the Blue Ridge Parkway or Skyline Drive in the Shenandoah National Park. But, like them, the Natchez Trace has scenery, beauty, historic landmarks, picnic areas, hiking trails, campgrounds, welcome centers, wildflowers, and wildlife.

Unlike them, however, the Natchez Trace also has the haunting remains of a plantation mansion, a former town site, nearby Civil War battlefields at Shiloh and Vicksburg, miles of split-rail fencing, and the Nation's second largest Indian mound (earthenworks thought to have been used for burials and religious ceremonies). Perhaps of greatest interest to the highway community, however, the Natchez Trace Parkway starts off at its northern terminus with the award-winning Double Arch Bridge.

More on that later.

The Trace, established as a national park in 1938 but not completed until 2005, winds 444 miles (715 kilometers) from the north just below Nashville, TN, continuing south across the Tennessee River into Alabama for a few miles, then crossing into Mississippi and through Jackson to Natchez, where it ends near bluffs overlooking the Mississippi River.

The parkway commemorates a footpath used by the Chickasaw, Choctaw, Cherokee, and Natchez Nations through their hunting grounds in the southern wilderness. In the late 1700s and early 1800s, the Trace was used by the "Kaintucks." The settlers from Kentucky and the Ohio River Valley floated their produce and livestock down the Mississippi River on wooden flatboats. Once they reached Natchez or New Orleans and had sold their crops—and their boats for lumber—they walked home via the Natchez Trace rather than fighting upstream against the current of the mighty Mississippi. With the coming of the steamboat to the Mississippi in the 1820s, the river could serve two-way traffic, and the Natchez Trace fell out of use.

The Trace's northern section in Tennessee rolls with the "ups and downs of hill country" (quoted from the National Park Service's official map), as it traverses the foothills of the southern Appalachian Mountains. In the spring—perhaps the best time to experience the parkway—the trails and roadsides are bordered by fields of wildflowers—from black-eyed Susans to crimson clover.

As the parkway continues south, it winds through pine woods and alongside sloughs and cypress swamps. Trails lead into the woods to waterfalls, and the roadway passes farms and alongside a few sections of the original Trace, preserved rather than paved over. In some places, visitors can walk through segments that are sunken deep into the ground, eroded by wagons, horses, and thousands of traders walking home to their farms in the Ohio Valley.

How the Trace Became a Parkway

Exhibits at the parkway's visitor center at milepost 266 near Tupelo National Battlefield in Mississippi tell the story. In addition to the

Visitors can stroll through a cypress swamp on this walkway at milepost 122, a few miles north of Jackson, MS.

This log cabin is adjacent to the gravesite of explorer Meriwether Lewis, best known for the Lewis and Clark expedition. Lewis died under mysterious circumstances while traveling the old Trace in 1809.

exhibits, the center sells a photo book by the Natchez Trace Parkway Association, *Building the Natchez Trace Parkway*, which contains numerous photographs of the construction crews and promoters who turned their vision into today's enjoyable road trip.

Most important from a transportation perspective, in 2005 the Federal Highway Administration's Eastern Federal Lands Highway Division completed a history of the pathway titled *The Natchez Trace: Path to Parkway*. The book contains priceless photos of early construction methods and equipment, plus engineering plans that include superstructure and construction sequence drawings of the Double Arch Bridge.

In 1905, a journalist named John Swain wrote an article, "The Natchez Trace," for *Everybody's Magazine* that generated considerable interest just as the Trace had started fading from public memory. Then, in 1909, the Daughters of the American Revolution began placing interpretive markers along the route. Good Roads associations also joined in the mission to remember the Trace.

Thanks to powerful friends, the Trace became a Federal road project to provide jobs and stimulate the economy during the Great Depression. In 1940, the National Park Service and the Public Roads Administration (a predecessor of the Federal Highway Administration) completed a survey of the old Natchez Trace.

Construction halted during the Second World War, but the Natchez Trace Parkway Association persisted and revived public support after the war. Still, obtaining rights-of-way and funds for construction took more than 67 years from the groundbreaking on September 16, 1937, to completion of the final section on May 21, 2005.

The construction was an exemplary model of interagency collaboration between the National Park Service and FHWA's Office of Federal Lands Highway. According to *Path to Parkway*, "From the very beginning, the 'park road' aesthetic values used in other national

At milepost 180.7, this meadow and split-rail fencing is next to the French Camp "stand," an inn that opened in 1812. The innkeepers at the Trace's regularly spaced stands provided food and places for travelers to spend the night.

parks was the operative in designing and constructing the parkway." Curvilinear alignments that minimized excavation and embankment followed the lay of the land.

Along the way, in 1996, FHWA Administrator Rodney Slater (later U.S. Transportation Secretary) presented a plaque to Superintendent Daniel Brown of the National Park Service, designating the parkway as one of America's Byways® and an All-American Road—a title indicating a nationally significant route that provides an exceptional traveling experience.

The Double Arch Bridge

Completed in 1994, the elegant Double Arch Bridge is one of 442 bridges on the parkway. This crown jewel crosses over Tennessee Highway 96, which passes through Birdsong Hollow. An engineering feat, the bridge won the 1995 Presidential Design Award and numerous other awards for its innovative design. FHWA's *Path to Parkway* notes that it was "the first segmentally constructed arch bridge in America."

The bridge is 1,648 feet (502 meters) long and rises 155 feet (47 meters) above the valley it spans. It cost $11.3 million and took 2.5 years to build.

The arches were constructed of 122 segments cast offsite, each weighing 36 to 45 tons (33 to 41 metric tons). During construction, six pairs of cables and three pairs of backstay cables provided support for the arches. When both arches were complete, the cables were removed.

"During the preliminary design, the engineers were planning to use spandrel columns on top of the arches to support the superstructure," says Hratch "Rich" Pakhchanian, a bridge engineer with the Office of Bridges and Structures headquartered at FHWA's Eastern Federal Lands Highway Division. "Then they realized that spandrel columns were not necessary since post-tensioning was to be used." Eliminating the spandrel columns resulted in an elegant bridge that preserves an unimpeded view.

Commemorating the Natchez Trace and its remarkable Double Arch Bridge is especially appropriate during this year's celebration of the National Park Service's 100th anniversary.

Norah Davis is the editor of PUBLIC ROADS magazine.

For more information, see https://www.nps.gov/natr/index.htm or contact Norah Davis at 828-877-4070 or norah.davis@icf.com.

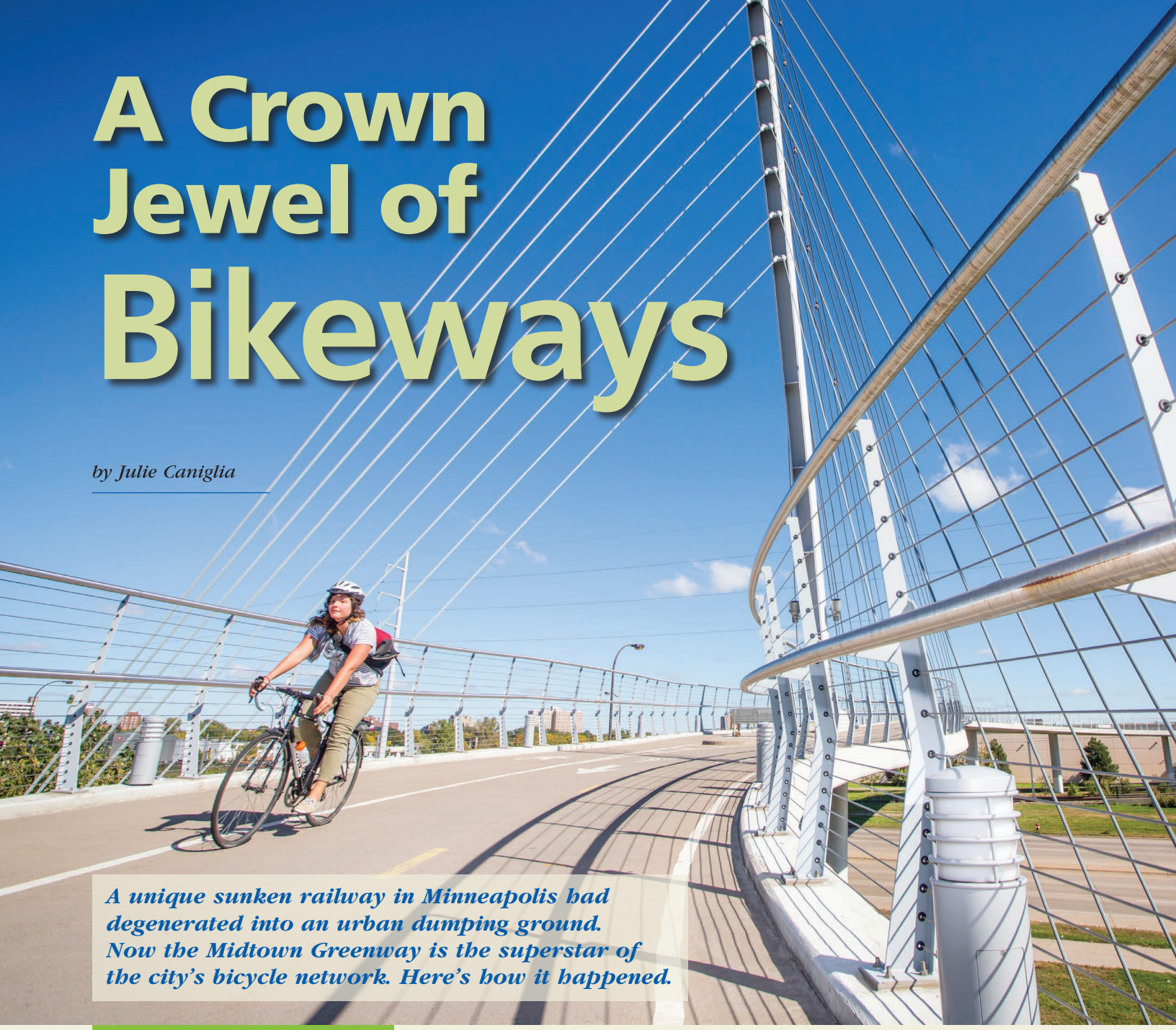
All photos by Norah Davis.

The Natchez Trace Parkway winds 444 miles (715 kilometers) through peaceful scenery.

Seen here from the valley below, the Double Arch Bridge spans Tennessee Highway 96.

A Crown Jewel of Bikeways

by Julie Caniglia



A unique sunken railway in Minneapolis had degenerated into an urban dumping ground. Now the Midtown Greenway is the superstar of the city's bicycle network. Here's how it happened.

(Above) The Sabo Bridge, shown here, is one of 28 connection points along the Midtown Greenway, a well-developed pedestrian and bicycling network in Minneapolis. *Photo: Philip Hussong for Hennepin County.*

The Midtown Greenway spans the heart of south Minneapolis, MN, from the Chain of Lakes on the west to the Mississippi River on the east. Originally part of a freight corridor for the Chicago, Milwaukee, St. Paul and Pacific Railroad, by the 1990s the trains had largely stopped running. Instead, the corridor attracted crime and contributed to blight nearby in already struggling neighborhoods.

Twenty years later, the greenway hosts more than a million trips a year as an almost barrier-free commuting option for bicyclists and an attractive green space for pedestrians. *USA Today* named the corridor one of the top urban bike paths in the country in 2013, and the Rails-to-Trails Conservancy entered it in the Rail-Trail Hall of Fame in 2015. Critical to this journey from urban blight to community gem was Hennepin County's Community Works initiative. As one of the initiative's first and most successful projects, the Midtown Greenway has helped Minneapolis—the largest city in Hennepin County—earn accolades as a bicycle-friendly city.

In 2010, *Bicycling* magazine named Minneapolis the best U.S. city for biking. It has all been

downhill since then—in a good way. In 2014, the U.S. Census Bureau named Minneapolis the number 2 city for commuting by bike, and in 2015 it was the first and only U.S. city to crack the top 20 on the Copenhagenize Index, a global ranking of bicycle-friendly cities. Together with St. Paul, MN, Minneapolis hosted the first Winter Cycling Congress in the United States in February 2016. In addition, the city has a long-term plan to nearly double its current network of 226 onstreet and offstreet bikeways, supplementing the plans of Hennepin County to add 20 miles (32 kilometers) annually to the county's 651-mile (1,048-kilometer) bike network.

Of all those miles, it is the 5.5-mile (8.9-kilometer) section that makes up the Midtown Greenway that has drawn the most attention, from locals and from around the world. By many counts, it also draws the most use. Up to 5,000 people a day ride or walk this route. Flat, direct, and almost totally car free, its utility is indisputable. One local newspaper described it as "high[ly] trafficked, ideal for many commutes, and essential to city transportation."

But utility does not explain fully the affection so many have for the greenway. That may have more to do with the experience it offers cyclists and pedestrians. For nearly 3 miles (4.8 kilometers), it runs as a corridor below the city's main street grid, which literally sets the greenway apart from its urban surroundings. The route is a relatively quiet, peaceful, green world—even a bit rural. Overhead, 37 bridges, 27 of them historic, span the greenway at regular intervals, like the rungs of a giant ladder, creating rhythmic patterns of light and shadow for those moving underneath.

Another factor is the history of the greenway itself. As with many rail-trails, that story includes neglect, abandonment, and ultimately reclamation as a beloved community asset—the kind of 21st-century green infrastructure that is key to creating more livable, attractive, and economically vital urban areas. The story also involves innovation: from government agencies, from partnerships, and from a large-scale, long-term effort to rescue an urban area sinking in economic quicksand.

The Greenway's Origins

In 1882, the Chicago, Milwaukee, St. Paul and Pacific Railroad (Milwaukee Road) laid track for its main line along what was then the southern edge of Minneapolis. By the early 20th century, however, the city had grown beyond the tracks. With trains crossing dozens of densely built residential streets at grade, conflicts—and deaths—were inevitable. Local residents began pressuring the Minneapolis City Council to address

This map shows the Midtown Greenway as a continuous offstreet bikeway through the heart of south Minneapolis, connecting the regional Chain of Lakes parks and offstreet bikeways to the west with the Mississippi River and bikeways on the east. The small green circles indicate access points and the blue lines are major onstreet bikeways. *Source: Hennepin County.*

The Greenway Guy

By the 1990s, the Milwaukee Road rail trench saw less and less rail traffic, and more and more garbage.

the issue and in 1910 the railroad company proposed a 2-year project to sink its tracks below street level.

This proposal was unique for its time, as other railroad grade separations from that era involved elevating the tracks or building roads over or under tracks. This distinction led to the sunken portion of the line being listed, in 2005, on the National Register of Historic Places—though in May 2016 the Minnesota Department of Transportation released a preliminary draft of a reevaluation that discusses the ramifications of keeping, altering, or revoking that historic designation.

No sooner was the agreement to sink the tracks made with the railroad than another legal battle ensued, this time prompted by businesses along the tracks that now stood to lose railroad access. In July 1912, the Minnesota Supreme Court heard a lawsuit on the project, at the time the second-largest public works project in Minnesota's history, and ruled in favor of the city of Minneapolis. One hundred years ago, in 1916, the Milwaukee Road completed the project, which included the trench and more than three dozen bridges to preserve the city's street grid.

A Long Decline

Fast-forward 75 years, to the early 1990s. Freight traffic was drying up in the rail corridor and the trench was becoming a literal dumping ground. One contributor to a railroad photography Web site recalls encountering a barricade of "bikes, shopping carts, and mattresses" in the trench. As Hennepin County Commissioner Peter McLaughlin put it, "You had to make sure your tetanus shots were up to date" if you elected to walk there. Realistically, people feared worse than a scrape from rusty metal. Crime rates and blight were on the rise in and around the railroad trench, in what is known as the Midtown Corridor: a mix of modest residential neighborhoods and industrial buildings (by then, many of them vacant).

Lake Street is also part of that area. A major east-west thoroughfare through Minneapolis, Lake Street runs parallel to much of the rail corridor, about a block away. The decline of this commercial street was especially apparent. It had retained its vitality well into the 1950s, even as the city dismantled its streetcar line and auto dealerships moved in, but stressors mounted. Businesses decamped to the suburbs, the State built I–35 West to both bisect and bypass the street, and adult-themed businesses took up residence in the 1970s and 1980s. And an economic and symbolic blow occurred in 1994 when Sears closed its 13-story, 1.2-million-square-foot (110,000-square-meter) tower on Lake Street, which dated back to 1928.

In 1995, Minneapolis endured a record-setting 97 murders, leading to a notorious front-page "Murderapolis" profile in *The New York Times* in 1996. Hennepin County officials regarded the downward trajectory with alarm. They convened an unprecedented Parks and Public Works Commission, which included members of the Minneapolis City Council, school and park boards, county commissioners, and representatives from business, trade, and development organizations, to assess the scope of the problem and find ways to turn it around.

Sparking a Comeback

The members of the Parks and Public Works Commission focused on a property map produced by the county Assessor's Office. The map highlighted the fact that the only properties in Minneapolis holding or gaining value were adjacent to lakes, parks, or parkways. The commission expanded on those findings in a report, published in June 1994, titled *Hennepin Community Works.* The title is a reference to the Depression-era Works Progress Administration and its public infrastructure projects. The report confirmed a "strong correlation" between higher home values in Minneapolis and the city's renowned system of parks connected by parkways and trails. The report noted that "the farther one gets from the park system, the fewer higher value homes there are." In fact, the commission found that parks in the city's declining areas tended to be isolated, rather than linked into the network via parkways or trails.

One of the commission's proposals was to create "new value" in these areas by connecting the isolated parks—and nearby residents—to the larger system with new or expanded trail and parkway corridors. This type of corridor would not only improve "the physical quality of the communities," but also would "enhance [their] social and economic viability." The report lists more than two dozen places for "projects that emphasize community linkage," including the "29th Street Corridor"—aka the Midtown Corridor.

"Community Works was fundamentally set up as an effort to get reinvestment in the county's urban areas that were struggling," says Commissioner McLaughlin. "We didn't just invest in the corridor. We knew that government can't do it alone, so where appropriate, we partnered with organizations like Allina Health and Wells Fargo to catalyze investment along the corridor."

Meanwhile, other elements had aligned to help gather momentum for transforming the derelict rail

corridor into the Midtown Greenway. One was public ownership of the Milwaukee Road rail corridor. Since 1980, the Hennepin County Regional Railroad Authority—a distinct governmental entity established by the county in accordance with State statutes—had been acquiring disused rail corridors for eventual light rail transit development. In 1993, the rail authority purchased the corridor.

Another element was the shared vision for a bicycle/pedestrian trail along this urban corridor, similar to those in use on other rail corridors owned by the rail authority. (Today, all 55 miles [86 kilometers] of the county-owned rail corridors have trails.) Two trail advocates, volunteers George Puzak and Tim Springer, had been promoting the idea with slideshows for neighborhood groups along the rail corridor; they called it a "cycling highway" to promote bicycling as transportation, not just recreation. They and other volunteers began meeting as the Midtown Greenway Coalition in 1992, which became a nonprofit in 1995 and a key partner—along with Hennepin County and the city of Minneapolis—in the newly formed Midtown Community Works project.

An 8-Year Buildout

By 1999, a master plan was in place for the Midtown Greenway as a central element of an urban planning and revitalization effort along the entire Midtown Corridor, including Lake Street. The first 3-mile (4.8-kilometer) greenway segment opened less than 1 year later, merging with the North Cedar Lake Regional Trail at the city's western border and terminating at 5th Avenue.

A second segment opened in 2004, bringing the greenway east to Hiawatha Avenue (State Highway 55), where it made a timely connection with the region's brand-new light rail transit line. The greenway's third and final segment, completed in 2006, extended to West River Parkway on the Mississippi River.

The following year, Hennepin County completed the Martin Olav Sabo Pedestrian Bridge, enabling bicyclists and pedestrians to bypass the light rail tracks and the seven lanes of Hiawatha Avenue. This suspension bridge is named for the longtime U.S. Representative from Minnesota, who died in March 2016. He was known for his leadership on the bipartisan National Transportation Policy Project and for acquiring funding for numerous transportation projects, especially pedestrian and bicycling projects.

The greenway itself features one trail with two lanes for bicyclists and one lane for pedestrians. More than two dozen access points include street-level entrances, ramps, and stairways. Like the city's other multiuse paths, the greenway is maintained year-round and is often cleared of snow even before local streets are, much to the delight of users. As one of them noted in February 2016 on Twitter: "@midtowngreenway gets . . . gold medal for consistency & plow speed. Seriously. Well done."

In keeping with the reason for the purchase of the rail corridor, land on the greenway's south side is reserved for transit service, though a development timeline remains uncertain. A 2014 alternatives analysis recommended a double/single track rail option, supplemented with enhanced bus service on Lake Street extending east into St. Paul. The Midtown Greenway Coalition, however, staunchly advocates streetcar service.

"We are convinced that it makes the most sense, given how the greenway has evolved," says Soren Jensen, executive director of the coalition. "A version that has rails embedded in turf would be relatively low impact and help to keep the green in the greenway, and would be the quietest and least disruptive option for people on the trails or living nearby."

In the 1980s and 1990s, Hennepin County purchased some 55 miles (86 kilometers) of rail corridors for possible future transit use. There is no current commitment to develop transit on the greenway, but the south side of the corridor—the undeveloped green space shown here to the right of the trail—is reserved for it. *Photo: Hennepin County.*

Midtown Greenway Coalition

The Midtown Greenway's trails are plowed and fully accessible throughout the year, which is appreciated by a growing cohort of winter cyclists.

Spurring Real Estate Growth

Greenway transit may be dependent on the vagaries of politics and public funding at multiple levels, but in the meantime real estate development in the area is booming. Five residential complexes, totaling more than 1,200 units, were under construction in the fall of 2012, which is especially remarkable given that private real estate development was still emerging from the recession that began in 2008.

In fact, throughout that recession, development continued along the greenway. Altogether, between 2005 and 2014, $750 million in building permit activity occurred in the Midtown Corridor (that is, within a quarter-mile [0.4 kilometer] on each side of the greenway), according to a long-term evaluation of the Community Works initiative produced in 2014.

One development even provided a sunny sequel to the shuttering of Sears on Lake Street. In 2006, the gigantic facility reopened as the Midtown Exchange, with international dining and shopping at the Midtown Global Market, a headquarters for a major midwestern health care provider, a hotel, and more than 300 affordable and market-rate residences. The northern side of the Exchange includes entrances to the greenway and offers meeting rooms and patios that overlook it.

Although much of the residential development is situated along the western side of the greenway in such in-demand neighborhoods as Uptown and LynLake, smaller developments are in the works for the greenway's midsection. In addition, Greenway Heights, 42 affordable apartments designed for working families, opened in 2015, just east of the Midtown Exchange.

The greenway's effects on real estate are not limited to new construction. Property values overall in the Midtown Corridor increased, on average, by 98 percent between 2001 and 2013, compared with an average of almost 82 percent in nearby areas. Ultimately, the greenway has delivered on the Community Works mission to build long-term value in struggling areas through investments in green spaces and public works infrastructure.

A Greener, Growing Future

The value of the Midtown Greenway goes beyond attracting development and boosting property values. Preserving and adding to the natural component of the greenway remains critical because nearby public green space remains limited.

"We are pleased about the development that's taken place—this is almost entirely infill development, so it's making the city denser and bringing in new residents," says Commissioner McLaughlin. "But that means we need to balance private development with green spaces and public spaces, or else we've defeated the purpose of the greenway. So we are careful about preserving the original vision for it."

Keeping the balance includes several thriving community gardens, along with nearly 5,000 trees and shrubs planted by volunteers at annual Arbor Day celebrations. In addition, several private development projects resulted in plazas and public promenades built at street level. The promenades are accessible around the clock, like the greenway and city sidewalks.

It is all part of a long-term goal to increase activity not just on the greenway but also nearby. In spring 2016, Hennepin County completed a study that focused on improving connections between the greenway and Lake Street and surrounding neighborhoods. The study also identified 10 public places suited to placemaking efforts that would draw new users and contribute to neighborhood identity.

"That feeling of being in another world on the greenway is great,

The temporary signage shown here was part of a series of design experiments in 2015 to help people make connections between the greenway and nearby destinations. *Photo: Philip Hussong for Hennepin County.*

Hennepin County

More than three dozen bridges connect local streets above a sunken stretch of the Midtown Greenway, creating a light-and-shadow experience for bicyclists and pedestrians.

but it also means that it can be difficult to orient yourself to the rest of the city," says Lisa Middag, a county planner who led the study.

To better integrate the greenway and its surroundings, the Hennepin County study recommended a consistent wayfinding system to help people navigate to and from the greenway and safety improvements for cyclists and pedestrians at street level. Another recommendation of the study was to work with underserved communities to encourage codevelopment of public spaces that are welcoming to more diverse users, so they can benefit by using the greenway for commuting, relaxation, or exercise.

"[The greenway] gets a lot of attention as a commuting route, but it's also a great place for families to ride or walk," says the coalition's Jensen. "In fact, it's great for anyone who's learning to ride—it's the ultimate protected bikeway."

He believes that ease of use helped the Midtown Greenway play a catalytic role in Minneapolis' recent bike renaissance. After all, biking in the city increased 53 percent between 2007 and 2015. For most of those years, two of the five busiest locations for pedestrian use were on the greenway, where pedestrian traffic increased 26 percent during the same period.

Ease of use also seems key to continued success, given the ambitious plans for more protected bikeways at both the city and county levels.

"To meet our goals for bike use, we need to increase the numbers of people who feel comfortable enough to bike more places, more frequently. That makes protected lanes essential," says Kelley Yemen, Hennepin County's bicycle and pedestrian coordinator. More people on new bikeways and the now-iconic greenway will reinforce each other as biking in the region continues to grow.

Transit service would further boost greenway usage. Many people eye the bridge that once carried Milwaukee Road trains over the Mississippi River as an eventual expansion and connection into St. Paul's bike network—though there are numerous hurdles, not least that the bridge is still owned and used by a private rail company.

Still, it's nice to dream. Especially when it does not diminish what the Midtown Greenway is today: as *USA Today* summed it up, "Exhibit A in why Minneapolis is considered the best bike city in America."

Check Out @midtowngreenway!

Local bicyclists are quite active on social media, and especially vocal about their pride and joy, the Midtown Greenway.

Julie Caniglia served as a communications specialist at Hennepin County from 2014 to 2016, and currently works for the Minneapolis Park and Recreation Board as a communications representative. She has written extensively on urban planning, design, and livability topics, as well as arts and culture in the public realm. She received a B.A. in art history from Carleton College.

For more information, see midtowngreenway.org or hennepin.us/midtown, or contact Hennepin County Community Works at 612-348-9260.

What Drives Highway Safety Improvements?

by Dana Gigliotti and Karen Scurry

FHWA is rolling out new requirements for performance-based decisionmaking. Take a look at how the HSIP has changed, including the addition of safety performance management requirements.

In 2015, more than 35,000 people in the United States lost their lives in motor vehicle-related crashes. Every time a crash results in death or serious injuries, it affects countless families, friends, employers, and communities in ways that have lasting and far-reaching effects.

The Highway Safety Improvement Program (HSIP) is a Federal Highway Administration program that funds State safety projects intended to reduce fatalities and serious injuries. States may use HSIP funds for infrastructure improvements that address safety concerns (for example, intersection design, pedestrian crossings, and retrofits to reduce wildlife-vehicle collisions).

In 2012, FHWA embarked on a new and improved approach to managing HSIP. This core Federal-aid program now requires transportation performance management as a basis for improving highway safety. The new focus will enhance data-driven safety decisions, improve collaboration across a wide range of safety partners, provide transparency for the public, and, most important, save lives.

Legislation Outlines Changes to HSIP

Under HSIP, States receive in total approximately $2.3 billion annually to implement their programs of highway safety improvements. Congressional legislation establishes program requirements, and FHWA regulations further clarify and prescribe requirements. States then develop programs that best meet their needs.

The Moving Ahead for Progress in the 21st Century Act (MAP-21), which went into effect on October 1, 2012, continued HSIP as a core Federal-aid program and outlined

(Above) Full-scale crash tests like this one, performed by FHWA at the Turner-Fairbank Highway Research Center in August 2009, help in understanding the performance of safety features covered by HSIP.

some changes to the program. States are now required to regularly evaluate and update their strategic highway safety plans and post HSIP annual reports on FHWA's Web site.

The legislation also requires FHWA to establish performance-based measures for States to use in assessing the number and rate of fatalities and serious injuries. The objective is for States to invest resources in projects that collectively will make progress toward the achievement of the national goals.

Final Rules

FHWA published final rules for HSIP and safety performance management (safety PM) measures in the *Federal Register* on March 15, 2016, with an effective date of April 14, 2016. The HSIP final rule updates the HSIP regulation under Title 23 of the Code of Federal Regulations (23 CFR), Part 924, to be consistent with MAP-21 and the Fixing America's Surface Transportation (FAST) Act, and clarifies existing program requirements. The safety PM final rule adds Part 490 to 23 CFR to implement the performance management requirements in Title 23 of the United States Code, Section 150, and establishes the safety performance measures.

The HSIP final rule contains three major policy changes related to the update cycle for strategic highway safety plans, the content and schedule of States' HSIP reports, and the subset of the fundamental data elements of the Model Inventory of Roadway Elements.

The safety PM final rule establishes five safety performance measures to carry out HSIP. These measures are 5-year rolling averages for the following: (1) the number of fatalities, (2) the rate of fatalities per 100 million vehicle-miles traveled, (3) the number of serious injuries, (4) the rate of serious injuries per 100 vehicle-miles traveled, and (5) the number of nonmotorized fatalities and nonmotorized serious injuries. These safety performance measures are applicable to all public roads, regardless of ownership or functional classification.

The safety PM final rule also defines serious injuries, aligning the definition with the one given in the *Model Minimum Uniform Crash Criteria, 4th Edition* (available at www.mmucc.us). Having a standard definition for serious injuries—previously undefined by the Federal Government—will improve data quality and reporting across the Nation, resulting in improved countermeasures. The crash criteria define any nonfatal injury that results in one or more of the following injury types as serious: severe laceration resulting in exposure of underlying tissues, muscle, or organs, or resulting in significant loss of blood; a broken or distorted arm or leg; crush injuries; suspected skull, chest, or abdominal injury other than bruises or minor lacerations; significant burns (second or third degree burns) over 10 percent or more of the body; unconsciousness when taken from the crash scene; or paralysis.

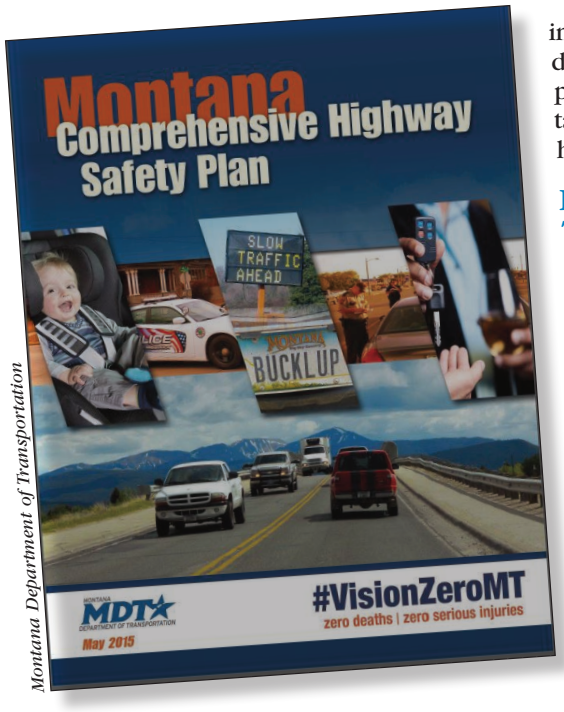
The safety PM final rule institutes a process for State departments of transportation and metropolitan planning organizations (MPOs) to establish and report their safety targets. States must set annual targets, which may include establishing separate targets for any urban area and a single nonurban target. (These separate targets will not factor in an assessment of the State's safety performance.) Three of the targets must be identical to National Highway Traffic Safety Administration targets for the required performance measures of the number and rate of fatalities and the number of serious injuries.

In addition, the safety PM final rule institutes a process for FHWA to assess whether a State has met, or made significant progress toward meeting, its safety targets. FHWA determines that a State has made significant progress toward meeting its targets when at least four of the five required safety performance measure targets are either met or the actual outcome for the target is better than baseline performance. If a State has not met its targets or made significant progress in pursuing those targets, FHWA will require the State to use certain safety funds only for HSIP projects and submit an HSIP implementation plan to FHWA.

Together, the HSIP and safety PM final rules will improve data, foster transparency and accountability, and enable safety progress to be tracked at the national level. The final rules will inform State DOT and MPO planning,

Transportation Performance Management

This strategic approach required by HSIP uses system information to make investment and policy decisions to achieve national performance goals. It provides key information to help decisionmakers understand the consequences of investment decisions across transportation assets or modes; improves communications between decisionmakers, stakeholders, and the traveling public; and ensures targets and measures are developed in cooperative partnerships and based on objective data. For more information, visit the FHWA Transportation Performance Management Web site at http://www.fhwa.dot.gov/tpm.



Montana Department of Transportation

programming, and decisionmaking for the greatest possible reduction in fatalities and serious injuries.

For more information on the rules, go to http://safety.fhwa.dot.gov/hsip/rulemaking or http://safety.fhwa.dot.gov/hsip/spm/measures_final_rules.cfm.

Strategic Highway Safety Plans

Strategic Highway Safety Plans are required under HSIP. These plans document various strategies to achieve long-term safety goals developed collaboratively with safety stakeholders across the State. The strategic highway safety plan guides the performance management processes that States use to determine and prioritize highway safety improvement projects. The process provides an opportunity to establish long-term goals and objectives, to which the annual HSIP targets can align.

MAP-21 and the FAST Act require, and the HSIP final rule specifies, a safety plan update and evaluation cycle, implementation practices, and goals that are consistent with the five safety performance measures established by the safety PM final rule.

By using a data-driven, collaborative approach to achieve safety gains, strategic highway safety plans have transformed how States identify roadway safety needs and make investment decisions. Since these plans were first required by legislation in 2005, traffic fatalities have declined dramatically. Over the past 10 years, the number of fatalities on the Nation's roadways has fallen nearly 25 percent.

Implementing The Final Rules

The HSIP final rule requires each State to update its strategic highway safety plan at least once every 5 years to identify and address any issues, and to confirm actions that the State will take to implement the plan's strategies.

For example, the Montana Department of Transportation recently updated its plan in cooperation with numerous safety partners and under the oversight of multiagency leadership and advisory committees. Together, these partners agreed on an interim long-term safety goal and set annual safety targets in the State plan.

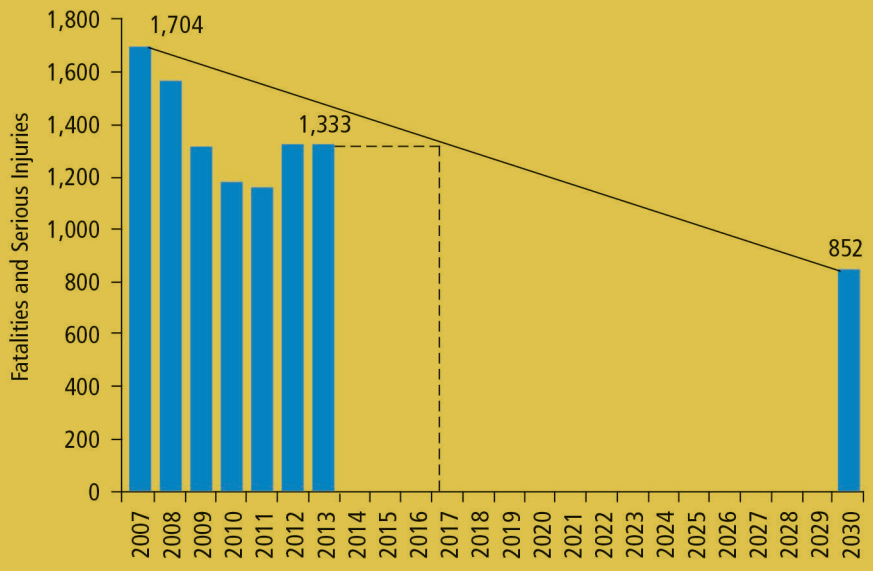
"Our update was the perfect opportunity to focus on coordinating our statewide goals, targets, and strategies," says Pam Langve-Davis, who is leading implementation of the State plan in Montana. "We are all striving to meet the vision of zero fatalities and zero serious injuries on Montana's roads, and now we have a cohesive strategy to get there."

Using Safety Data to Inform Decisions

Many States also are implementing the final rules by collecting data aligned with the Model Inventory of Roadway Elements to make performance-based safety decisions. MAP-21 requires FHWA to identify a subset of the more than 200 elements currently in the inventory that provide useful insight for roadway safety. FHWA identified 37 fundamental data elements and categorized them by functional class and roadway surface type for road segments, intersections, and interchanges. These data elements enable a jurisdiction to analyze crashes on their roadway network relative to the expected average crash frequency on roads with similar characteristics and traffic volumes. The inventory is available at http://safety.fhwa.dot.gov/rsdp/mire.aspx.

A variety of improved techniques for data analysis are now available to State and local agencies, such as those presented in the American Association of State Highway and Transportation Officials' *Highway Safety Manual*. These techniques are intended to assist in safety decisionmaking, but they are useful

Montana's Target for Reducing Fatalities and Serious Injuries, 2007–2030



The Montana DOT aims to reduce fatalities and serious injuries by one-half in a little over two decades, from 1,704 in 2007 to 852 by 2030.
Source: Montana Department of Transportation.

Data-Driven Safety Analysis

FHWA has made data-driven safety analysis a focus of its Every Day Counts initiative, which encourages States to adopt applications of predictive and systemic analysis in their safety management and project development processes. Predictive analysis uses crash, roadway, and traffic volume data to reliably estimate the safety performance—crash frequency and severity—of an existing or proposed roadway. This method can help a State quantify the safety impacts of its transportation decisions. Systemic analysis screens a roadway network to identify high-risk features correlated with specific severe crash types. Once identified, agencies can target high-risk locations with appropriate countermeasures. Both predictive and systemic techniques rely upon good safety data.

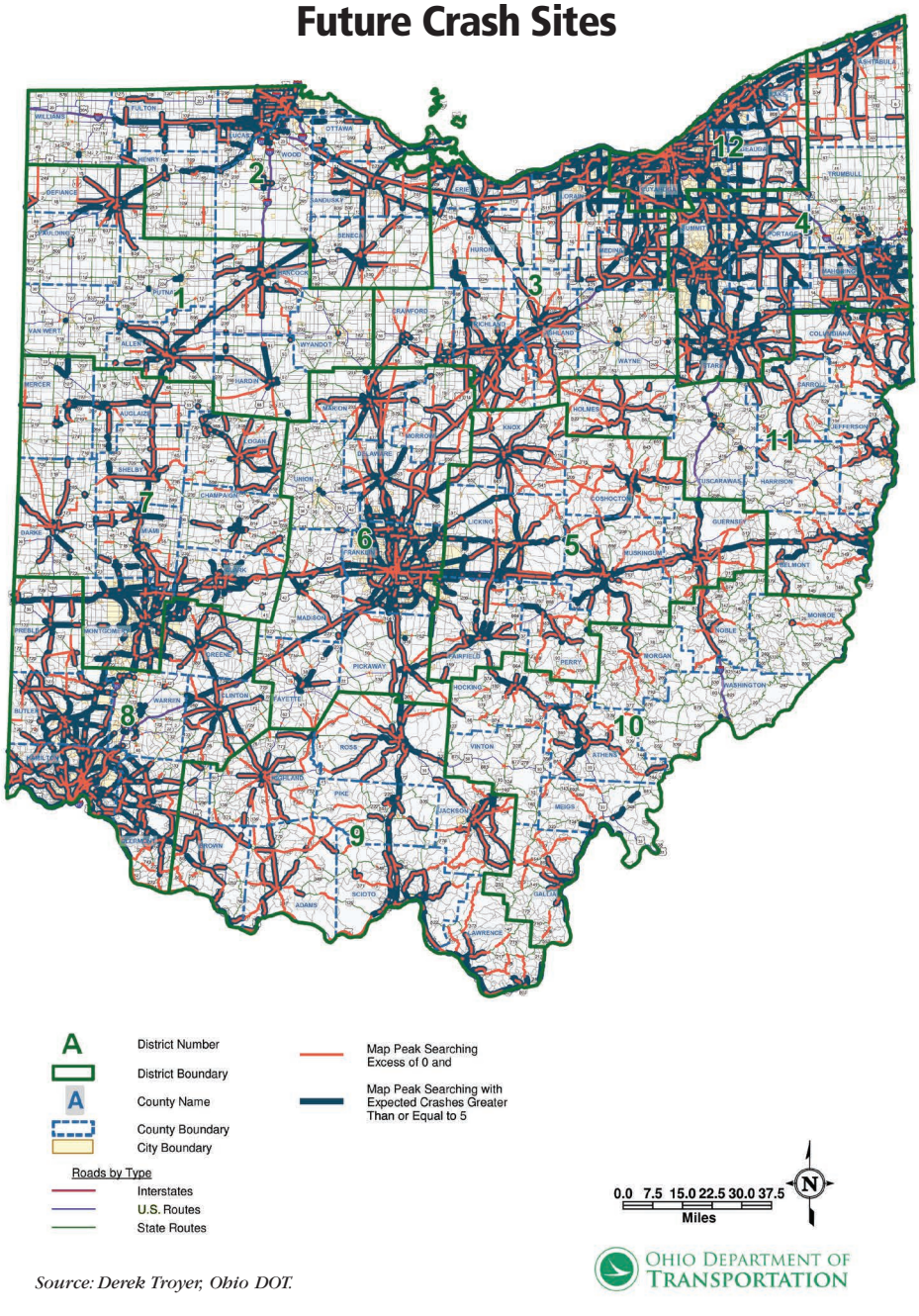
only if States have good, basic safety data, such as crash, roadway characteristic, and traffic volume data, to support them.

For example, the Ohio Department of Transportation (ODOT) uses various *Highway Safety Manual* techniques, including AASHTOWare Safety Analyst, to assist with numerous aspects of its safety management program. Included are network screening, problem diagnosis, countermeasure selection, economic appraisal, project prioritization, and countermeasure evaluation.

Traditionally, State DOTs and other transportation agencies have prioritized HSIP funding on sites that historically have been high-crash locations. ODOT uses a method presented in the *Highway Safety Manual* that combines predictive model crash estimates with historical crash data to obtain a more reliable estimate of crash frequency. The excess expected average crash frequency method evaluates a network of facilities for sites likely to respond to safety improvements. Using this method, States can prioritize locations that are experiencing more crashes than their peer group. The methodology enables users to target investments where crashes can be reduced statistically and ultimately save lives.

In addition, ODOT developed a location-based reference system to locate crashes geospatially, with roadway characteristics and traffic volume data. The agency also developed a curve and intersection inventory, and collects roadway and traffic information for roads both on and off the State system. Ohio then formats the data for use by analytic

Mapping Past and Predicted Future Crash Sites



Source: Derek Troyer, Ohio DOT.

Identifying problem road segments (shown in blue) based on calculating the expected crash frequency provides a similar result to past methodologies using crash rates and densities. But Ohio uses a method based on excess crash frequencies to identify road segments performing worse than their peers, which helps prioritize investments on segments (shown in orange) to reduce crashes long term.

Derek Troyer, Ohio DOT

The Ohio DOT collects data on roadway infrastructure using the ODOT PathRunner, a van equipped with a precision distance measuring instrument and an inertial measurement unit to precisely track the van's position relative to the roadway. The van collects data on road roughness, pavement distress, rutting, and surface macrotexture. It also creates a 3–D surface image and takes photos of the roadway environment in four directions, at a rate of 200 images per mile.

tools. Having data and tools available has greatly simplified routine analysis and evaluation activities.

"Ohio's safety data system has enabled us to better understand the impacts of proposed projects," says Derek Troyer, a safety engineer with ODOT. "Overall, this roadway safety management process is greatly assisting ODOT in implementing and managing its safety program."

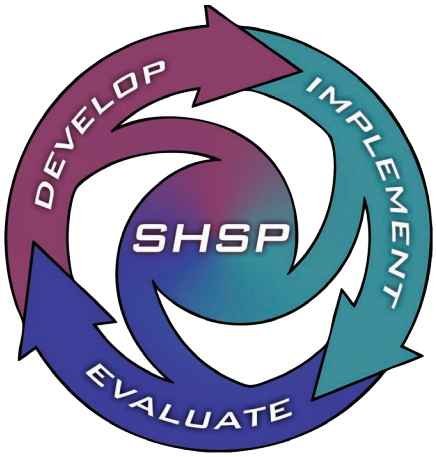
Resources for Implementation and Evaluation

FHWA has published guidance and other resources to help its partners implement the HSIP and safety PM final rules at http://safety.fhwa.dot.gov/hsip/rulemaking. The agency also provides technical assistance and training across the country to support implementation.

To help States update their strategic highway safety plans, FHWA created an evaluation process model and offers training to help States put the model into action. The training demonstrates an organized approach to evaluation that will help States answer important questions about the effectiveness of their strategic plans.

"Many States have elements of evaluation in place," says Jennifer Warren from FHWA's Office of Safety. "But by organizing these elements into a comprehensive program evaluation, States can realize additional benefits."

By regularly reviewing their safety data and the status of strategy implementation, States can get a good picture of their progress on safety goals and objectives. They can adjust their strategies as needed and integrate those changes into updates of the State strategic highway safety plan.



Training

The National Highway Institute recently began delivering a new, 2-day course, Transportation Performance Management for Safety (NHI-138006). Karen Miller, an organization performance specialist with Missouri DOT, attended the course. "It provides participants with a thorough understanding of the safety performance measures and how States and MPOs should consider various factors in setting targets," she says.

NHI also is planning a course, Steps to Effective Target-Setting and Progress Assessment, that will provide a more indepth look at various ways to set performance targets across safety and other transportation programs. Visit www.nhi.fhwa.dot.gov/home.aspx for more information on the safety course and, when it becomes available soon, the target-setting course.

In addition, the FHWA Office of Safety and the Resource Center, in coordination with the NHTSA and FHWA division offices, will offer free 1-day workshops on safety target setting and coordination beginning in winter 2016. The workshops will bring State safety stakeholders together to discuss safety performance requirements and assist States in reviewing their data for the first round of target setting.

Technical Assistance

To achieve safety performance goals, State DOTs, MPOs, State highway safety offices (SHSOs), and other stakeholders must collaborate more closely than ever to set targets, identify problems, and plan countermeasures.

FHWA identified current practices for setting safety targets and established guidance for coordination among agencies. Literature reviews and in-person interviews set the stage for seven comprehensive State workshops, whose participants represented State DOTs, SHSOs, FHWA, NHTSA, and MPOs.

The workshops led to a final report, FHWA's *Safety Target Coordination Report* (FHWA-SA-16-101), available at http://safety.fhwa.dot.gov/hsip/spm. The report includes a variety of noteworthy practices that States have used to advance safety performance measures. For example, the South Carolina DOT has collaborated with MPOs to analyze crashes in their respective regions and to hold workshops on safety data as part of their long-term planning process.

Roadway Data Improvement Program

In 2013, FHWA's Office of Safety developed the Roadway Data Improvement Program. The program's core activity is to

HSIP Key Dates

2017	• State DOTs, SHSOs, MPOs, and other stakeholders begin reviewing data and selecting targets for calendar year (CY) 2018.
July 2017	• SHSOs report on the three identical CY2018 safety targets to NHTSA. • States incorporate planned, specific, quantifiable, and measurable improvements for the collection of Model Inventory of Roadway Elements into the State traffic records strategic plan. This plan describes specific traffic records efforts and measurable anticipated improvements in the State's core safety databases.
August 2017	• State DOTs report CY2018 HSIP targets in the HSIP annual report to FHWA. • States update the strategic highway safety plan for consistency with MAP-21 requirements.
February 2018	• MPOs must establish CY2018 HSIP targets.
April 15, 2019	• States incorporate the new definition of serious injuries into their standards and processes.
December 2019	• Data become available for use by FHWA to assess States' achievement of CY2018 HSIP targets.
March 2020	• FHWA reports findings to States indicating whether they have met or made significant progress toward meeting CY2018 HSIP targets.
June 2020	• If a State does not meet or make significant progress toward meeting its targets, it must submit an HSIP implementation plan to FHWA by June 30, 2020, and spend certain safety funds only on safety projects in fiscal year 2021 (beginning October 2020).
September 2026	• States must have access to the complete collection of the fundamental Model Inventory of Roadway Elements by September 30, 2026. • States continue to collect and use the fundamental data elements from the Model Inventory of Roadway Elements to improve safety on all public roads.

assemble a group of subject matter experts to review and assess a State's procedures for data collection, analysis, management, governance, and interoperability. The team also assesses how well the State works with local agencies in sharing and exchanging data, and then reports its findings and makes recommendations for improvements. Since its formation, the program has conducted assessments for 10 States and for the National Park Service.

"The Roadway Data Improvement Program is exactly what the Alaska Department of Transportation and Public Facilities needed to hone our highway safety program," says Jack Stickel, who managed the department's Geospatial Engineering Services Section within the Information Systems and Services Division when the assessment took place in Alaska. "The program provides an awesome opportunity to get highway safety stakeholders together for 2 days, break down silos, and facilitate communications with data stewards. The insights and recommendations from the program team were right on and will play an instrumental role in improving our department's highway safety programs."

Next Steps

States are beginning to update their strategic highway safety plans, set safety performance targets, and collect and use Model Inventory of Roadway Elements to support a performance-based HSIP. In support of these efforts, States should review and update their existing processes to ensure consistency and compliance with the HSIP and safety PM final rules, but also, more important, to ensure that they are identifying and implementing the best solutions to address their safety needs.

States also should immediately take steps to meet the specific deadlines and requirements related to establishing and reporting safety targets, submitting annual HSIP reports, updating strategic plans, incorporating the new definition of serious injuries into standards and processes, and collecting and using the Model Inventory of Roadway Elements.

Under HSIP, States are spending approximately $3 billion per year to implement life-saving strategies, projects, and programs. But the benefits of this Federal-aid program extend even further. HSIP influences statewide policies that advance implementation of proven, effective countermeasures across entire roadway systems. In addition, improved data collection and analysis that result from the HSIP and safety PM final rules will not only improve safety decisionmaking, but also will influence all project development decisions through performance-based practical design. Through these efforts and further cooperation, the Nation will move closer to zero deaths on its roadways.

Dana Gigliotti is a transportation specialist with FHWA's Office of Safety, where she leads efforts to implement safety performance management requirements. She has a bachelor's degree in health sciences from Towson University.

Karen Scurry is a transportation specialist with FHWA's Office of Safety, where she supports implementation of the Highway Safety Improvement Program and promotes the use of crash modification factors in transportation decisionmaking. Scurry holds both a bachelor's and a master's degree in civil engineering from Rutgers University. She is a registered professional engineer in New Jersey.

For more information, see http://safety.fhwa.dot.gov/hsip or contact Dana Gigliotti at dana.gigliotti@dot.gov or 202-366-1290 or Karen Scurry at karen.scurry@dot.gov or 609-637-4207.

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

New Pedestrian and Transit Facility Opens At U.S.–Mexico Border

Deputy Federal Highway Administrator David S. Kim recently joined U.S. General Services Administrator Denise Turner Roth and U.S. Ambassador to Mexico Roberta Jacobson, as well as other State and local officials, to open the new Virginia Avenue Transit Center and the West Pedestrian crossing at the San Ysidro Land Port of Entry in southern California.

San Diego Association of Governments

Federal, State, and local officials helped open the new pedestrian crossing facility at the San Ysidro Land Port of Entry, shown here.

The new pedestrian crossing, just west of I–5, includes a transit facility and features 10 northbound processing lanes with 2 reversible lanes that will be open around the clock. The crossing will connect with the Virginia Avenue Transit Center, serving as a main northbound crossing point and connection to bus options for pedestrians.

The center will accommodate buses, taxis, pedicabs, and dropoffs and pickups by private vehicles. Both projects are a part of the modernization and expansion of the San Ysidro Land Port of Entry, which, once completed, will help the San Diego area's economy. According to the San Diego Association of Governments, San Ysidro is the busiest land border crossing in the western hemisphere, serving an estimated 70,000 northbound vehicles and 25,000 pedestrians per day. It also represents the third-highest dollar value of trade among all land border crossings between the United States and Mexico.

Technical News

Alaskan Bridge Tests GRS–IBS in Harsh Climate

The Federal Highway Administration, in cooperation with the Gwichyaa Zhee Gwich'in Tribal Government, started construction in August 2016 on Alaska's first geosynthetic reinforced soil–integrated bridge system (GRS–IBS) project. The project to replace Ivars Bridge over the Sucker River in Fort Yukon, 11 miles (18 kilometers) north of the Arctic Circle, will test the technology in an extreme environment that has seen a record high of 100 degrees Fahrenheit (38 degrees Celsius) and a record low of 78 degrees Fahrenheit below zero (-61 degrees Celsius).

The replacement of Ivars Bridge, shown here before the start of construction, is the first GRS–IBS project in Alaska.

The current bridge is overtopped occasionally by the stream and is failing because of scour of the fill material around the culverts. Overtopping creates a hardship for the locals as the bridge is the only stream crossing available. Its failure would virtually eliminate the opportunity for subsistence usage on one side of the stream. The project is expected to be completed in fall 2017.

Public Information and Information Exchange

Nogales Street Project Improves Key Freight Corridor

FHWA Deputy Administrator David S. Kim and California State and local officials recently attended a ceremony to open the Nogales Street grade separation project, which improves safety, reduces noise and emissions, and enhances freight movement in Los Angeles County, CA. The project is central to the Alameda Corridor-East Trade Corridor Plan in southern California to connect the Nation's rail network to the Ports of Los Angeles and Long Beach.

The $88.7 million project, which relied on $22 million in Federal funding, separates the two major rail lines from local highways in the City of Industry, a Los Angeles suburb. These east-west rail lines run parallel with SR–60, a critical freight highway, moving freight between the Ports of Long Beach and Los Angeles, and the rest of the country. Running north-south, Nogales Street provides

important access to SR–60 for the commercial and logistics shipping industry.

Nogales Street carries more than 45,000 vehicles daily. Where the street intersects with the railroad, the route's traffic is halted for the passage of more than 50 trains per day, of which nearly 80 percent are freight carriers. The new six-lane roadway underpass and double-decker railroad bridge will eliminate these sizeable traffic delays, along with the potential for collisions at the highway-rail grade crossing. The project also will substantially reduce noise from train horns and emissions from cars and trucks idling while waiting for trains to pass.

FHWA Publishes Primer on Shared Mobility

FHWA recently released *Shared Mobility: Current Practices and Guiding Principles* (FHWA-HOP-16-022). The publication is a primer on shared mobility, which is an innovative transportation strategy that enables travelers to gain short-term access to transportation, including vehicles, bicycles, or other modes, on an as-needed basis.

The term "shared mobility" includes various forms of carsharing, bikesharing, ridesharing (carpooling and vanpooling), and on-demand ride services. It can also include alternative transit services, such as paratransit, shuttles, and private transit services (called microtransit), which can supplement fixed-route bus and rail services.

In addition to innovative travel modes, new ways of transporting and delivering goods also are emerging. These courier network services have the potential to change the nature of the package and food delivery industry, as well as the broader transportation network.

Shared mobility is having a transformative impact on many cities by enhancing the accessibility of transportation, while simultaneously reducing driving and personal vehicle ownership. The primer provides an introduction and background; reviews success stories; examines challenges, lessons learned, and proposed solutions; and concludes with guiding principles for public agencies. It also looks toward the future of the evolution and development of shared mobility.

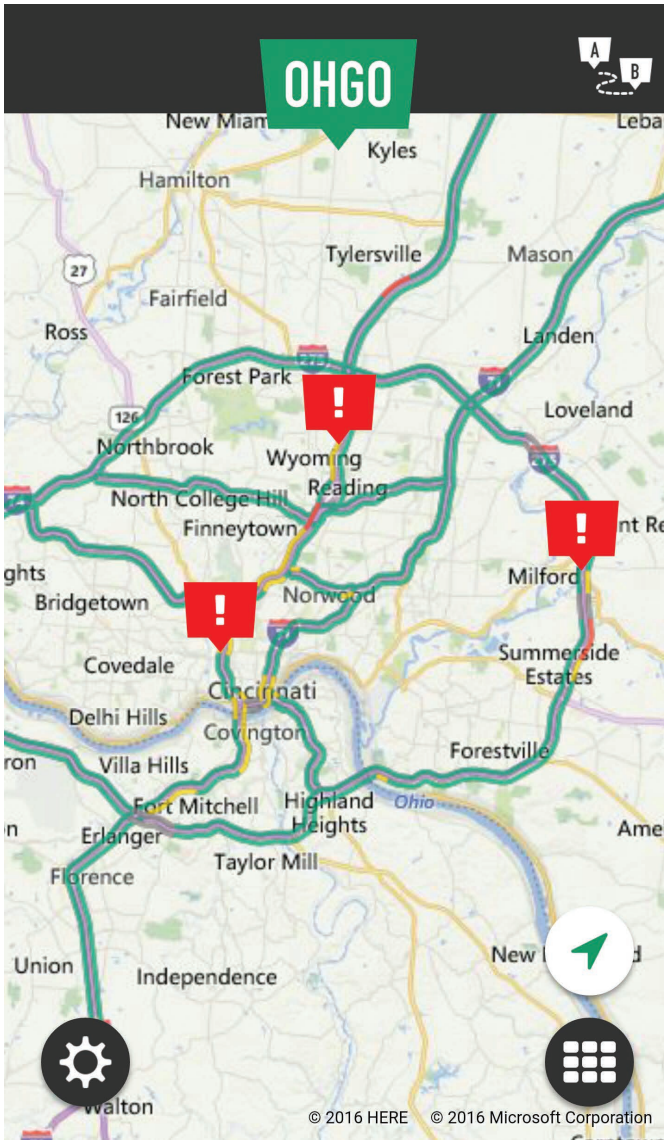
The primer is available at www.ops.fhwa.dot.gov /publications/fhwahop16022/fhwahop16022.pdf.

ODOT Traffic App Improves Commuter Experience

The Ohio Department of Transportation (ODOT) recently released a mobile app with customizable traffic alerts, information on road construction and travel delays, and hands-free voice capabilities for travelers on the go. The app, called OHGO, is available in the App Store and Google Play.

OHGO uses information from ODOT's speed sensors to identify delays, offers real-time traffic maps, and enables users to access traffic cameras to view their routes. Traffic operators at ODOT's traffic management center in Columbus verify and add incidents to the app.

Users can save their regular routes and schedule mobile notifications about traffic delays along those routes, as well as receive notifications for a specified distance around their current location.



ODOT

ODOT's traffic app includes warnings of roadway incidents (the red exclamation points) verified by operators at Ohio's traffic management center in Columbus.

For more information, visit www.dot.state.oh.us /pages/ohgoapp.aspx.

ODOT

FHWA Partners with States to Protect Pollinator Health

Bees and butterflies are responsible for about 30 percent of the U.S. food supply and 90 percent of wild plants, making the health of these pollinator populations an issue that affects everyone. But pollinators are at risk. In 2015, beekeepers reported losing about 40 percent of honey bee colonies, and the number of overwintering monarch butterflies in Mexico's forests has declined by 90 percent or more over the past two decades.

The transportation community has an opportunity to play an important role in keeping these populations

healthy and thriving by turning transportation corridors into pollinator-friendly habitats.

FHWA and six States recently signed a partnership to strengthen the pollinator community, which includes bees and monarch butterflies, along I–35 from Texas to Minnesota—a key migratory corridor for monarchs. The agreement establishes "a cooperative and coordinated effort to establish best practices and promote public awareness of the monarch butterfly and other pollinator conservation." The partners will work together to develop a unified branding for I–35, informally naming it the "Monarch Highway."

Jim Hudgins, U.S. Fish and Wildlife Service

FHWA and six States signed an agreement to establish habitats for monarch butterflies, like this one, and other pollinators along I–35.

In addition, the White House Pollinator Health Task Force recently released a *Pollinator Partnership Action Plan* that builds on Federal actions to improve pollinator health by facilitating additional engagement with States, transportation agencies, and the private sector. The plan furthers a presidential memorandum signed in June 2014 that focused the attention of Federal agencies on the plight of pollinators. It provides examples of successful collaborations between the Federal Government and other stakeholders to support pollinator health and highlights areas for future cooperation.

For more information, visit www.transportation.gov /fastlane/keeping-highways-safe-bees-butterflies-and -other-pollinators and www.whitehouse.gov/sites /whitehouse.gov/files/images/Blog/PPAP_2016.pdf.

Washington State Opens Longest Floating Bridge

The Washington State Department of Transportation recently celebrated the grand opening of the SR–520 floating bridge over Lake Washington. The 7,700-foot (2,350-meter)-long bridge—the world's longest floating bridge—was built using the design-build project delivery method. The new bridge replaces one that opened in 1963 with a safer structure that offers more roadway and transit capacity.

After more than half a century of use, the old bridge needed to be replaced. The original's pontoons were vulnerable to windstorms, and its support columns were vulnerable to earthquakes. In addition, the old bridge only had two lanes in each direction, no shoulders, and no high-occupancy vehicle (HOV) lanes. Adding transit/HOV lanes, shoulders, and a bicycle and pedestrian path on the new bridge provides greater travel reliability and more options to accommodate growth in the region.

Washington State DOT

The aging original SR–520 bridge (right) remained in use until the new floating bridge (left) opened to traffic in spring 2016.

The new bridge is currently open to traffic while construction of the bicycle and pedestrian path continues. When completed in 2017, the path will connect to regional trails on either side of Lake Washington, creating additional opportunities for recreational use.

For more information, visit www.wsdot.wa.gov /Projects/SR520Bridge.

Washington State DOT

Personnel

Aylward Selected as New Volpe Center Director

In July, Anne Aylward, a senior leader with more than 30 years in the transportation field, was selected as the director of the John A. Volpe National Transportation Systems Center. She is the organization's seventh permanent director, and the first woman to hold the position. Aylward's new role builds on her 20 years of service at Volpe, during which she made substantial contributions to USDOT priorities and led a research and technology staff of 490 analysts, economists, engineers, planners, scientists, and system developers.

Aylward also co-led Volpe efforts on numerous high-visibility priorities, including USDOT's "Beyond Traffic" report and FHWA's first National Freight Strategic Plan. Under her guidance, Volpe hired hundreds of talented professionals, including a significant increase in women, both as new employees (from 32 percent in 2011 to 57 percent in 2015) and those promoted into leadership roles. Aylward also has strengthened relationships within USDOT and with other partners, helping increase the value of Volpe's research portfolio by nearly 20 percent over the past 5 years.

For more information, visit www.volpe.dot.gov /news/anne-aylward-is-new-volpe-director.

Internet Watch

by Carrie Boris

Online Tool Promotes Health Through Transportation

Everyone benefits from using roadways, streets, sidewalks, trails, and public transportation for everyday needs. These essential elements of the built environment help travelers get to and from work and school and access basic necessities like grocery stores and health services. However, transportation infrastructure also can contribute to harmful effects, including decreased air quality from vehicle emissions and a lack of safe places to walk, bicycle, and engage in physical activity without unnecessary risk.

Increasingly, State officials, metropolitan planning organizations, and other partners are including health goals and criteria in transportation planning, policies, and project selection. The public health community has begun to partner with transportation planning agencies to integrate health considerations in transportation work.

But effective planning and decisionmaking require the right data. That's where the Transportation and Health Tool can help. Launched in 2015 by the U.S. Department of Transportation and the Centers for Disease Control and Prevention, in partnership with the American Public Health Association, the simple-to-use tool highlights the connection between transportation and public health and can help improve transportation decisionmaking.

Indicating Healthy Improvements

The Transportation and Health Tool provides data on a set of 14 transportation and public health indicators for each State and metropolitan area. These indicators describe how the transportation environment affects safety, active transportation, air quality, and connectivity to destinations. The indicators help communities see how they perform in comparison to other States or communities on a variety of transportation measures. For example, walking, bicycling, and transit tend to support healthy physical activity, so indicators in the tool provide measures of how many people are using these methods to get around.

Transportation decisions also affect surrounding communities. For example, transportation has a major impact on air quality, so the tool includes indicators that relate to how much people drive and how close people live to roads with heavy traffic.

Many other indicators in the tool give policymakers an immediate understanding of the critical relationships between transportation investments and health, including the affordability of an area's housing and transportation. Indicators also measure an area's safety performance through traffic fatalities and seat belt use.

After looking up State or local results on the interactive Indicator Data page, users are directed to 25 strategies that transportation practitioners can use to improve health outcomes, including such methods as expanding infrastructure for walking, bicycling, and transit; promoting connectivity; and improving roadway safety.

The strategies section of the site identifies and describes evidence-based policies, strategies, and interventions. Each detailed strategy page includes an overview, the related indicators, positive health outcomes, supporting evidence and practical examples, and resources for more information.

The site also includes a literature and resources section that identifies five primary pathways through which transportation influences public health—active transportation, safety, cleaner air, connectivity, and equality—and explains the indicators related to each. In addition, the site provides indicator profiles and an explanation of the scoring methodology to help users understand the data used in the 14 indicators and analysis used to arrive at the percentile-based scores.

A Collaborative Effort

USDOT, the Centers for Disease Control and Prevention, and the American Public Health Association worked together, with input from a panel of experts, to select transportation and health indicators for the tool. The panel chose the 14 indicators from an initial list of 190 through an intensive process over several months, culminating in a 2-day workshop in 2013.

"We designed the tool to be a useful resource for transportation decisionmakers around the country," says Barbara McCann, director of USDOT's Office of Policy Development, Strategic Planning, and Performance. "It provides transportation and public health officials with a starting point for discussion on how transportation investments can help protect human health."

The online tool is a one-stop source for data for State and local transportation decisionmakers and health officials to understand how their transportation systems might affect health. "For the first time," McCann says, "this site compiles data on how all States and communities are performing on a range of health-related transportation indicators."

For more information, visit www.transportation.gov/transportation-health-tool.

Carrie Boris is a contributing editor for PUBLIC ROADS.

by Judy Francis

Taking Tunnel Inspections to a New Level

The Federal Highway Administration estimates that there are more than 470 highway tunnels in the United States. Many of these tunnels are more than 50 years old and are quickly reaching the end of their designed service lives. But, until recently, tunnel owners and operators lacked Federal guidance for conducting mandatory tunnel inspections.

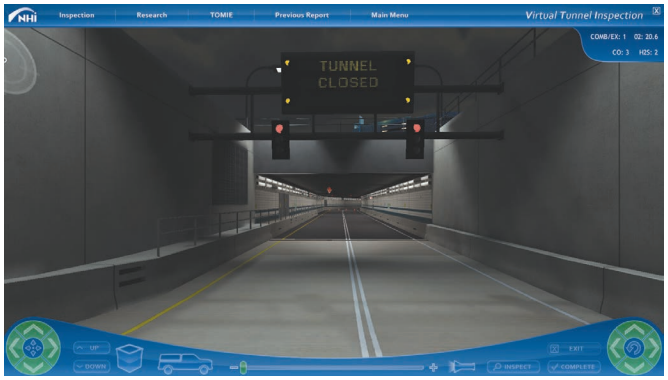
In July 2006, the importance of tunnel inspection gained national attention when part of the I-90 Central Artery Tunnel in Boston, MA, collapsed, killing a motorist. In addition, the affected portion of the tunnel remained closed for 5 months for repairs, causing significant traffic delays and productivity losses.

The incident led the National Transportation Safety Board to suggest, among other recommendations, that FHWA seek legislative authority to establish a mandatory tunnel inspection program similar to the National Bridge Inspection Standards. Signed in July 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) mandated such a program, and in August 2015, FHWA established the National Tunnel Inspection Standards. MAP-21 also called for a program to train appropriate personnel to carry out tunnel inspections, and that is where course developers with the National Highway Institute (NHI) stepped in.

Virtual Technology in Training

FHWA worked with NHI to develop content for course 130110, Tunnel Safety Inspection. Building on the virtual technology NHI used to create its award-winning bridge inspection training, developers incorporated that technology into the new course.

The Tunnel Safety Inspection course uses virtual technology as an alternative to traditional field inspections. The capstone case study is a tunnel inspection that takes place in a computer-simulated, 3-D environment, exposing participants to a variety of conditions unlikely to be found during a single real-world inspection. The simulation also enables participants to demonstrate what they have learned without the time or budgetary expense required for traditional field trips.



Using virtual technology, shown in this screen capture, enables training participants to experience tunnel inspections without time-consuming and costly trips into the field.

"Due to congestion, security, and vulnerability issues, it is impractical to arrange for onsite inspection of tunnels as part of the training," says Rodolfo Maruri, a bridge engineer at FHWA. "The virtual inspection provides an alternative that enables course participants to go through the same procedures as required in onsite inspection of tunnels. The technology provides the opportunity to achieve NHI's training objectives in a controlled environment that simulates actual conditions and helps ensure that future tunnel inspections are done consistently nationwide."

Interactive Learning

The 5-day, instructor-led training consists of nine highly interactive modules. Participants work through a series of case studies, giving them an opportunity to practice and apply their knowledge through simulations of real-life tunnel inspections. The course covers everything an inspector needs to know to execute a successful inspection. At the end, participants can identify critical structural, civil, mechanical, electrical, signage, lighting, fire safety, and security elements, as well as recommend an appropriate inspection frequency.

Prior to enrollment, participants must complete one of three prerequisite courses: Engineering Concepts for Bridge Inspectors (130054), Introduction to Safety Inspection of In-Service Bridges (130101), or Prerequisite Assessment for Safety Inspection of In-Service Bridges (130101A). NHI strongly recommends that participants complete Safety Inspection of In-Service Bridges, or possess equivalent field experience. A background in the design or safety inspection of in-service tunnels or bridges is also helpful, but not required.

Incidents like the ceiling collapse in Boston's Central Artery Tunnel underscore the safety imperative for tunnel inspections, and NHI's training helps ensure that tunnels are safer, more secure, and maintained in a state of good repair.

For more information or to register for a course, visit the NHI Web site at www.nhi.fhwa.dot.gov.

Award-Winning Virtual Technology

In 2015, FHWA received the International Association for Continuing Education and Training's Innovation of the Year Award for Technology Integration for incorporating the virtual bridge technology into course 130055, Safety Inspection of In-Service Bridges. The award recognizes the best of the best in technology integration and innovation.

FHWA and NHI continue to innovate using this technology, most recently expanding its use to training on tunnel inspection. And, in June 2016 NHI piloted two additional virtual bridges—a steel truss bridge over a railroad and a concrete tee beam bridge—in its in-service bridge inspection course.

Judy Francis is a contracted marketing analyst for NHI.

Communication Product Updates

Compiled by Lisa A. Shuler of FHWA's Office of Corporate Research, Technology, and Innovation Management

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

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

National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
Telephone: 703–605–6050
Toll-free number: 1–888–584–8332
Web site: www.ntis.gov
Email: customerservice@ntis.gov

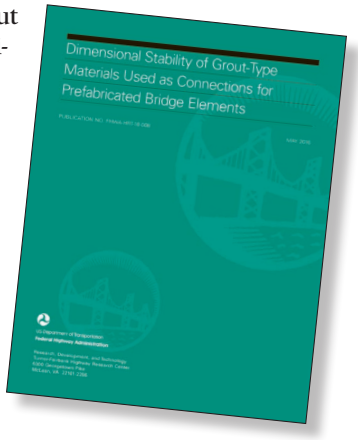
Requests for items available from the R&T Product Distribution Center should be addressed to:

R&T Product Distribution Center
Szanca Solutions/FHWA PDC
700 North 3rd Avenue
Altoona, PA 16601
Telephone: 814–239–1160
Fax: 814–239–2156
Email: report.center@dot.gov

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

Dimensional Stability of Grout-Type Materials Used as Connections for Prefabricated Bridge Elements (Report) Publication Number: FHWA-HRT-16-008

This report discusses research focused on addressing performance concerns related to the dimensional stability (primarily early-age shrinkage) of 11 commercially available grouts and grout-like materials. Bridge engineers and material specifiers have observed that some materials in these classes, especially those classified as nonshrink grouts, may display significant dimensional instability when used in connection details during bridge construction projects. This shrinkage results in cracking and leakage through the grout or at interfaces with prefabricated components.



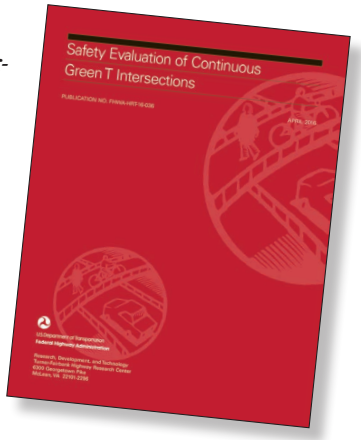
This report summarizes research demonstrating the types of shrinkage expected from these grouts, the shortcomings of commonly used test methods, alternative test methods that may better demonstrate real-world performance, and an innovative way of minimizing the shrinkage observed in some of the grouts.

The most common test methods used to evaluate dimensional stability are described in the ASTM (formerly the American Society for Testing and Materials) C1107 test method. After an initial evaluation, researchers found that the methods in this specification consider several parameters simultaneously, providing a qualitative approach that is only useful for comparative purposes. To evaluate the variety of parameters more completely, researchers assessed volume changes from a fundamental standpoint, measuring pure expansion and shrinkage deformations via test methods such as ASTM C157 and ASTM C1698. Results showed that most of the grouts evaluated in this research performed well in terms of dimensional stability when tested in accordance with ASTM C1107.

However, separate testing to assess autogenous and drying deformations (shrinkage and expansion) demonstrated that ASTM C1107 is not necessarily an appropriate means to capture the full range of critical dimensional stability behaviors. Given the fact that most of the cement-based grouts commonly exhibit shrinkage, this research also included additional tests focused on mitigating partial shrinkage by including internal curing through the use of prewetted lightweight aggregates.

This report is available to download at www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/16008/index.cfm.

Safety Evaluation of Continuous Green T Intersections (Report) Publication Number: FHWA-HRT-16-036



The continuous green T intersection is characterized by a channelized left-turn movement from the minor street approach onto the major street, along with a continuous through movement on the major street. The continuous through movement typically has a green through arrow indicator to inform drivers that they do not have to stop.

This report documents research conducted as part of FHWA's Evaluation of Low-Cost Safety Improvements Pooled Fund Study to provide crash modification factors and benefit-cost economic analyses for targeted safety strategies.

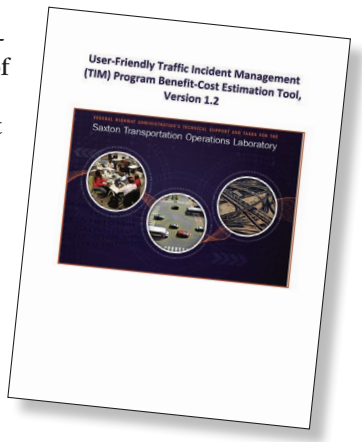
Past research has consistently demonstrated operational and environmental benefits from implementing the continuous green T intersection at three-leg locations when compared with a conventional signalized T intersection. These benefits include reduced delays, fuel consumption, and emissions. The safety effects of the conventional signalized T intersection are less clear. Past research has been limited to a small sample of intersections in a single State and used only simple statistical comparisons from reported crash data.

To overcome the statistical challenges associated with prior safety studies and improve product reliability, researchers used a propensity scores-potential outcomes framework—which can be used to mimic a randomized experiment—to compare the safety performance of the continuous green T intersection with the conventional signalized T intersection. The study examined 30 treatment sites and 38 comparison sites from Florida, and 16 treatment sites and 21 comparison sites from South Carolina. Results showed that the expected total, fatal and injury, and target crash (rear-end, angle, and sideswipe) frequencies were lower at the continuous green T intersections relative to the conventional signalized T intersections.

The benefit-cost analysis indicated that the continuous green T intersection is a cost-effective alternative to the traditional, signalized T intersection. The report also provides additional details and results of the safety evaluation.

The document is available to download at www.fhwa.dot.gov/publications/research/safety/16036/index.cfm.

User-Friendly Traffic Incident Management (TIM) Program Benefit-Cost Estimation Tool, Version 1.2 (Report) Publication Number: FHWA-HRT-16-055



Traffic incidents contribute significantly to the deterioration of the level of service of both freeways and arterials. Traffic incident management (TIM) programs have been introduced worldwide with the aim of mitigating the impact of traffic incidents on safety and roadway performance. These programs support quick incident response, thereby shortening incident duration, and control traffic demand around the incident scene.

Some TIM programs can be costly to taxpayers. Therefore, it is important for transportation agencies to evaluate the benefits of TIM programs and determine the associated return on investment. Benefit-cost estimation studies for TIM programs have employed a range of estimation methodologies and monetary equivalent conversion factors. Consequently, resulting benefit-cost ratio estimates vary widely.

This report includes an overview of TIM (various strategies and their benefits, costs, and stakeholders) and methodology information (selected strategies, duration and proportion-based estimation, data collection based on microscopic simulation, benefit estimation modeling, cost calculation, the benefit-cost ratio, and additional benefits).

The report also discusses a benefit-cost tool with standardized methodology that can be employed universally and equitably in estimating benefit-cost ratios for different TIM programs. This is essential for establishing consistency and greater confidence in the validity of results. With access to the methodology in the form of a simple-to-use, less data-intensive tool, TIM programs and taxpayers alike can benefit from cost-effective evaluations.

The report also includes a case study of the I–95 Corridor Coalition in New York. The case study features a comparison of the effectiveness of implementing three selected TIM strategies—safety service patrol, driver removal laws, and dispatch colocation. It also advances an understanding of the need for a standardized tool to estimate benefit-cost ratios and the effectiveness of the developed TIM benefit-cost tool.

The report is available to download at www.fhwa.dot.gov/publications/research/operations/16055/index.cfm. The tool is available at www.fhwa.dot.gov/software/research/operations/timbc.

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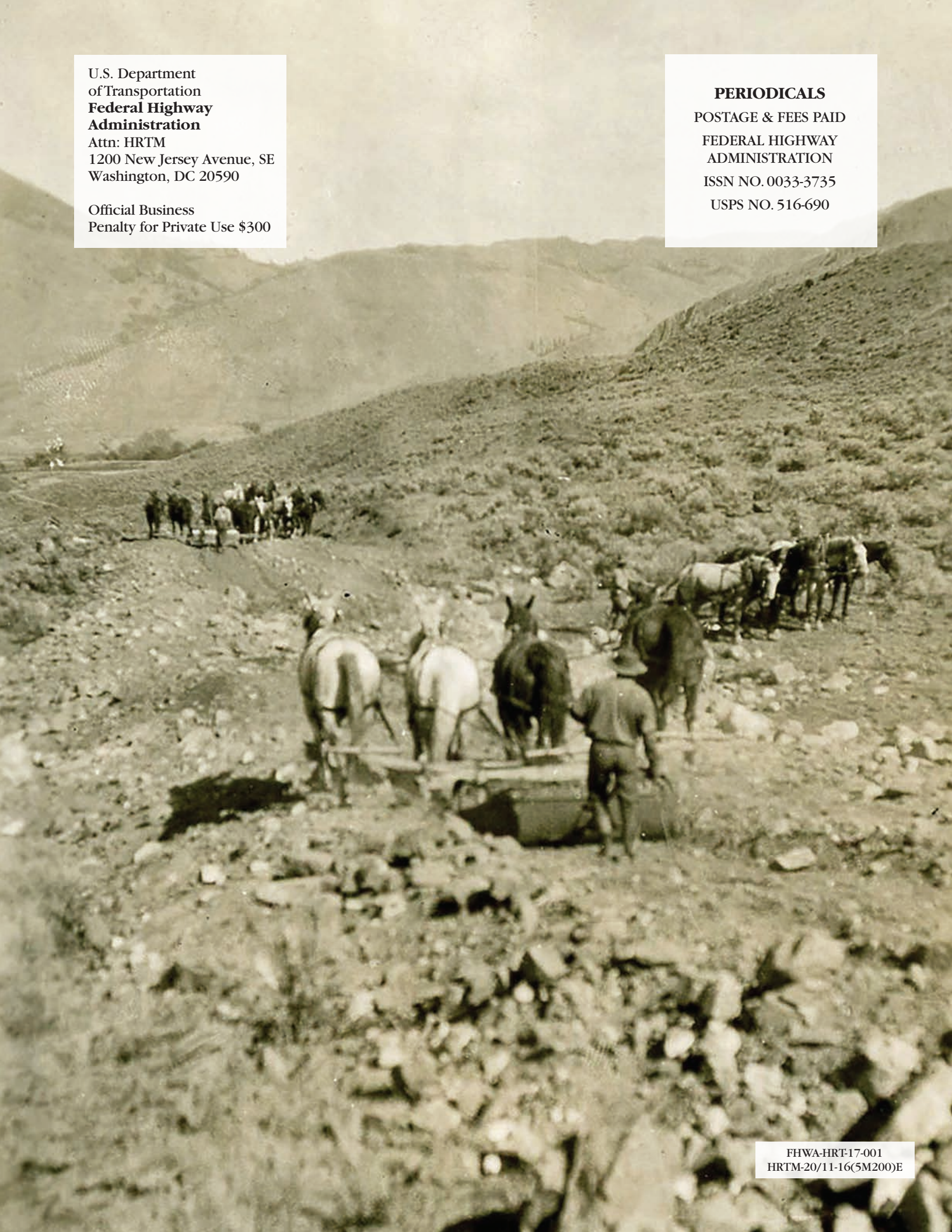

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