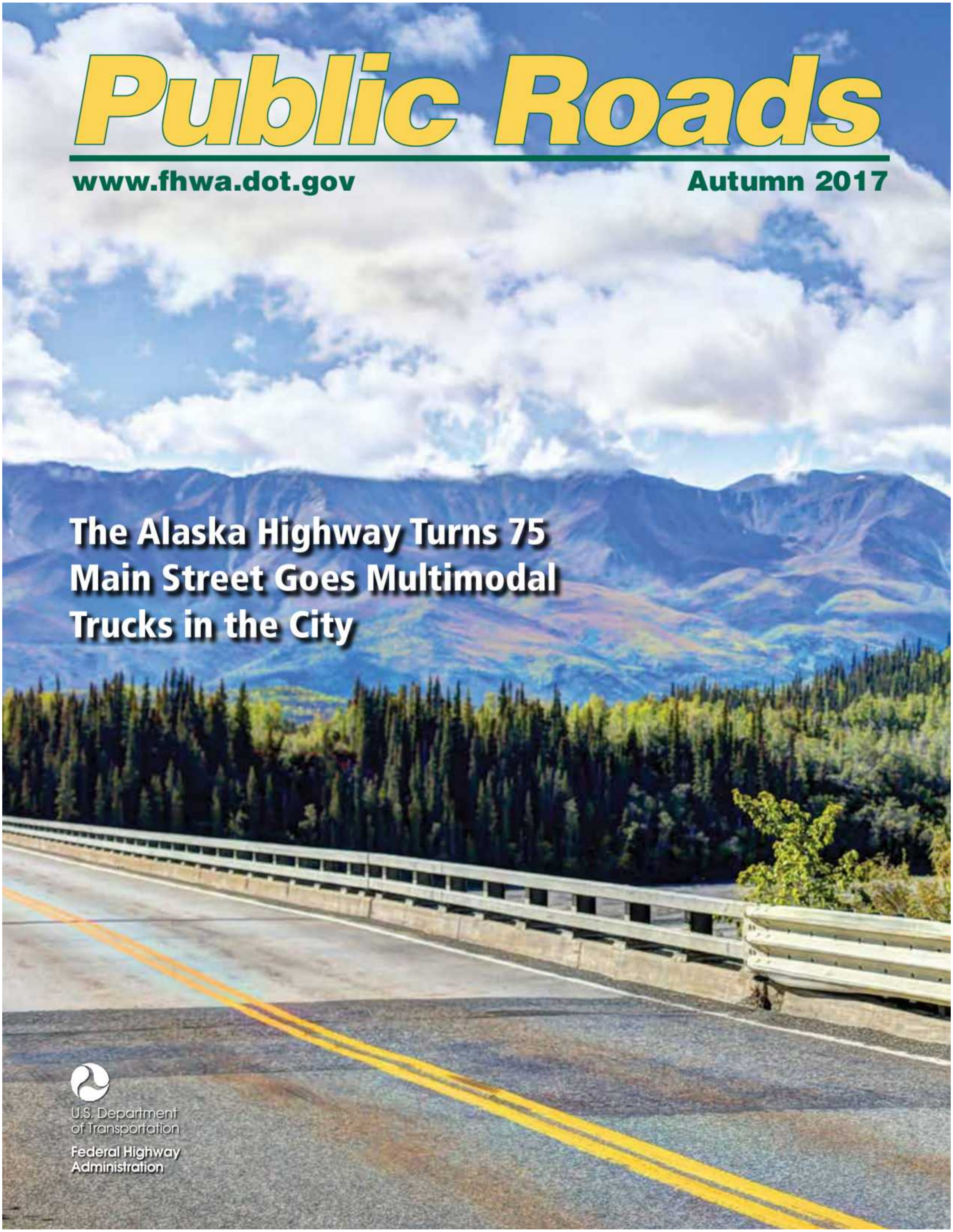
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Main Street Goes Multimodal
Trucks in the City
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Public Roads

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

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Front Cover—This glorious view of the Alaska Highway near Milepost 1348 shows the Robertson River Bridge, which is about 120 miles (193 kilometers) north of the Canadian border where the famous highway enters Alaska from the Yukon. Construction of the road was completed in November 1942, and improvements continued the following year—and for many years thereafter. To learn more, see "America's Glory Road" on page 10 in this issue of PUBLIC ROADS. *Photo: Shelley Potter, Alaska Department of Transportation & Public Facilities.*

Back cover—Scenes like this one of a flooded road were commonplace in 2017 in Florida, Puerto Rico, Texas, and elsewhere because of Hurricanes Harvey, Irma, and Maria, and other storms. The job for States is to make transportation infrastructure more resilient in the face of extreme weather events, and FHWA is helping with an updated manual on assessing highway vulnerability in floodplains. For more information, see "Rivers, Rainfall, and Resilient Roads" on page 36 in this issue of PUBLIC ROADS. *Photo: © emptyclouds, Getty Images.*

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The Secretary of Transportation has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this department.

Guest Editorial

Leaves Are Falling, and Holiday Driving Is Not Far Away

What a year it has been. The Federal Highway Administration and the U.S. Department of Transportation have made great strides toward improving the safety of the transportation system, shortening project completion times, and adopting time-saving permitting practices—all of which are critical to keeping the Nation moving.

The agency responded to history-making hurricanes in Texas, Florida, Puerto Rico, and the U.S. Virgin Islands with manpower, cutting-edge technologies, and the Emergency Relief program. Many members of the FHWA team endured incredibly difficult conditions to ensure that State and territorial partners had the technical assistance and other resources they needed to reopen roads and bridges safely.

With Thanksgiving around the corner, this issue of PUBLIC ROADS offers a cornucopia of information about the diverse work FHWA does. For example, given the devastation caused by hurricanes and floods this year, "Rivers, Rainfall, and Resilient Roads" (page 36) is especially well-timed. The importance of proper, thorough planning for roads in floodplains has never been more important.

Black Friday and Cyber Monday, the year's busiest shopping days, will soon be here. Each underscores the role FHWA plays in keeping roads safe and efficient so commercial traffic can make deliveries on time. "Delivering the Goods" (page 20) offers new insights into the growing challenges facing freight shippers in and around busy urban areas.

And the thoughtful blend of research and artful prose in "America's Glory Road" (page 10) sheds new light on one of the greatest civil engineering achievements in U.S. history—the construction of the Alaska Highway 75 years ago. The article is not only a great read, but it also serves as an important reminder of the hardships highway workers and engineers have faced—and continue to face—building and maintaining the Nation's transportation infrastructure.

Much of the country will soon contend with icy highways. By taking

simple precautions, we can help keep each other safe throughout this challenging travel season. Please buckle up, and don't tailgate. Stay at least one car length behind the vehicle in front of you for every 10 miles (16 kilometers) per hour of speed. On icy roads, triple that distance—the more space the better. Remember that bridges and overpasses usually freeze first. Obey posted speeds, and err on the side of driving slower. Also, give snow removal equipment and emergency vehicles enough room to do their jobs. As we say in Indiana, "Don't crowd the plow!"

More than 37,000 people lost their lives on U.S. roads in 2016, and that is unacceptable. This year, we must bring that number down—and safe driving on wintry roads is key.

With a new Administration, a commitment to highway finance reform, and a trillion-dollar infrastructure plan under development, USDOT and FHWA have a perfect opportunity to strengthen the Nation's roads and bridges and focus on reducing deaths and serious injuries on U.S. roads.

Having led a State department of transportation, I know full well just how effective FHWA can be. Each of us has a role to play in making the Nation's roads safer. Some say it is an impossible challenge. I see it as an incredible opportunity, and hope you do too.

Brandye L. Hendrickson
Acting Administrator
Federal Highway Administration

HOT TOPIC

by Agnes R. Velez

Bringing International Experience To Performance Measurement

Globally, funding limitations and competition for resources require that transportation agencies increasingly focus on performance measurement in support of investment and policy decisions. In the United States, measuring performance has been in the forefront of recent transportation priorities. Recent Federal legislation has accelerated transportation agencies' efforts to develop and emphasize performance outcomes.

To implement a successful approach to transportation performance measurement, research organizations and governments at all levels must work in tandem. International engagements and partnerships provide an additional source of knowledge and experience based on other countries' approaches and lessons learned.

Strengthening Collaboration

Bringing together more than 120 governments, the World Road Association (WRA) is the only international intergovernmental organization focusing on technology transfer in matters related to road transportation. Through the Federal Highway Administration and the American Association of State Highway and Transportation Officials (AASHTO), the United States has increased its presence in the WRA's technical committees.

As part of U.S. participation in the WRA, AASHTO serves as the U.S. National Committee. Among other responsibilities, National Committee organizations ensure the dissemination of WRA-generated information within their respective national transportation communities and select representatives to serve on WRA's technical committees. (For more information, see "Leading on the International Stage" in the January/February 2017 issue of PUBLIC ROADS.)

The WRA operates on a 4-year cycle. For the 2016–2019 cycle, AASHTO nominated Christos Xenophontos as English-Speaking Secretary of the Technical Committee on the Performance of Transport Administrations. He is also the vice chair of AASHTO's Standing Committee on Performance Management, which provides State departments of transportation with the expertise and resources to support performance-based management.

Members of the World Road Association's technical committee met in Rhode Island to discuss the impact of implementation of performance measures around the globe.

"[The standing committee] addresses all aspects of performance management, including Federal regulations, current industry practices, and emerging approaches and concepts," says Xenophontos. "By linking with WRA's Technical Committee on Performance of Transport Administrations, we gain additional access to what other countries are already doing to improve the practice of implementing performance measures."

WRA's committee met in April 2017 in Providence, RI, for a 2.5-day session to discuss global perspectives and approaches. The meeting provided an opportunity for attendees to learn about the AASHTO committee, and also for the Rhode Island Department of Transportation to work with members of the WRA committee in organizing a mini-summit on connected and autonomous vehicles.

WRA's committee also is working with the Transportation Research Board's (TRB) Committee on Performance Management to highlight shared information, research results, and products. As part of the meeting in Rhode Island, the two committees organized a joint session to exchange information on developing strategies for performance management.

Members of the AASHTO, TRB, and WRA committees also presented during a session of the 2017 TRB Annual Meeting on the work undertaken by each committee. "TRB's [committee] can benefit from an extended international membership and [WRA's committee] can benefit from the extensive research undertaken by [TRB]," says Mara Campbell, the TRB committee chair.

International Perspectives

As a member of the WRA committee, FHWA's Francine Shaw Whitson serves as co-leader of the committee's working group that is undertaking a study to define concepts and measures used in establishing a strategic approach to achieving performance goals.

"Through interaction with the international road transportation community," says Shaw Whitson, "we benefit from lessons learned from countries that are more advanced in the implementation of [performance measurement] programs. We are gaining valuable firsthand insight to information not readily available by other means."

Members of the WRA committee have developed surveys to help define what makes a good strategic plan and what key performance measures countries have set to achieve desired goals.

"We are seeking to understand the impact of changes undergone in the transportation administrations and benefits and challenges associated with implementation of these changes," says José Manuel Blanco Segarra, chair of the WRA committee.

The final reports and case studies will not be available until WRA's 2019 Congress in Abu Dhabi. However, says Blanco Segarra, "the intent of the technical committee is to produce interim products that will be shared with the U.S. road transportation community through the links forged in this collaboration."

Agnes R. Velez is a transportation specialist with FHWA's Office of International Programs.

INNOVATION CORNER

by Tony Furst

Looking Out for Innovation

Innovation is critical to the transportation industry for many reasons. New processes and technologies can speed project delivery, improve safety, increase the durability of roads, better protect the environment, and help optimize the use of scarce financial resources. But introducing new processes and technologies comes with risk. Transportation agencies face an ongoing challenge to balance the benefits that new innovations can bring against the possible risks—financial, organizational, political, or otherwise.

"We are in an industry that approaches risk cautiously," says Jeff Zaharewicz, acting director of the Federal Highway Administration's Center for Accelerating Innovation. "But at the same time, we are an industry that relishes problem-solving. As new problems arise, we look for or develop new ways of solving them."

> "*We should be looking for solutions in conventional* and *unconventional places.*"
> *— Fawn Thompson, FHWA's AID Demonstration Grant Program Coordinator*

MoDOT tested an innovative protective coating, developed by the oil industry, to assess its performance for use on bridges. Shown here is the steel test plate before (left) and after the application. *Photos: Tesla NanoCoatings.*

The Center for Accelerating Innovation exists to help agencies overcome the barriers to deploying innovations—regardless of the genesis of the innovation. For example, the center offers the Accelerated Innovation Deployment (AID) Demonstration program to encourage transportation agencies to implement innovations in their projects. AID Demonstration grants provide funding, up to $1 million per project, to offset the cost of applying new technologies.

"Historically, the transportation industry has looked to its own research and development for solutions," says Fawn Thompson, coordinator for the AID Demonstration grant program. "But because many technologies and systems can span industries, we should be looking for solutions in conventional *and* unconventional places."

The goal is to consider the best ideas, no matter their source.

Offshore Inspiration in Missouri

A recent AID Demonstration project with the Missouri Department of Transportation (MoDOT) showcases how a new technology from outside the transportation industry was adapted for use on a highway project.

Practitioners at MoDOT learned of a protective coating that could significantly reduce the time it takes to paint steel bridge elements. The main application of the product was in the offshore oil drilling industry, not in transportation.

"We were skeptical at first," says Bill Dunn, a structural liaison engineer at MoDOT. "But the technology appeared to be applicable to bridges. So, before we jumped in, we got samples and did our own testing. Once we verified the results, we decided to try it on a project."

MoDOT started with a relatively low-risk effort. "For this first project, we chose a bridge that was not in the most difficult environment," Dunn says. "That allowed us to have a test case before we use the coating more widely. We're easing into it."

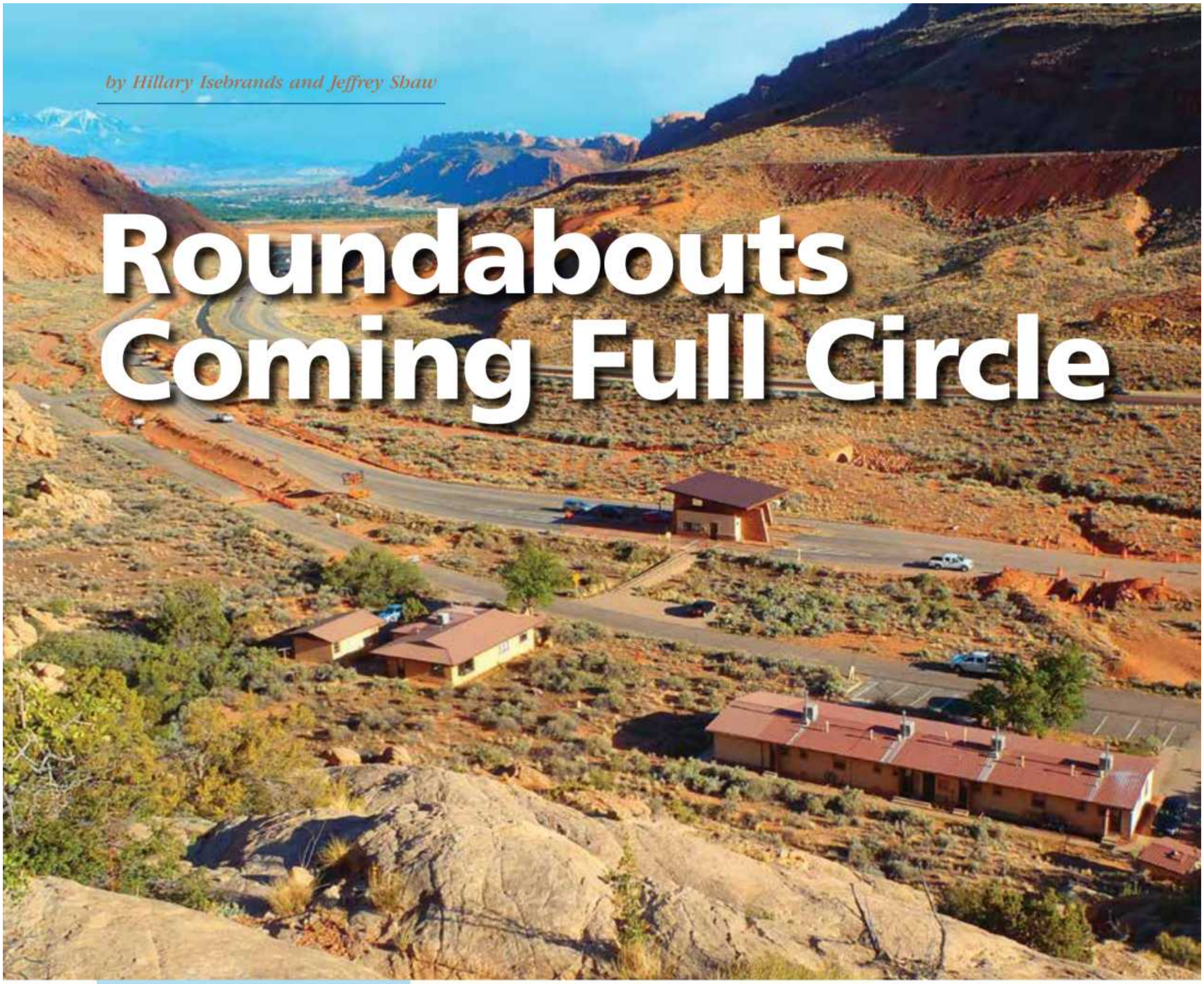
The Center for Accelerating Innovation encourages this kind of measured approach—test, assess, and then look for opportunities for wider adoption.

"Managing risk is different than being risky," Zaharewicz says. "Managing risk means evaluating the technology, exploring its impacts, and performing due diligence. You then determine if the risk is worth the reward. If so, try it."

Other States have expressed interest in MoDOT's project, says Dunn. "[They] are watching to see how it goes. If it is successful, they may field the technology as well."

Dunn's advice to other transportation agencies? "Be open, but be diligent. We owe it to the citizens of our State to spend their dollars as wisely as we can. If you're not open to new technologies, I don't think you can say you are doing that."

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



Roundabouts Coming Full Circle

by Hillary Isebrands and Jeffrey Shaw

Checking the progress of the modern designs reveals they now number in the thousands across the United States. Maybe they're right for your next intersection makeover?

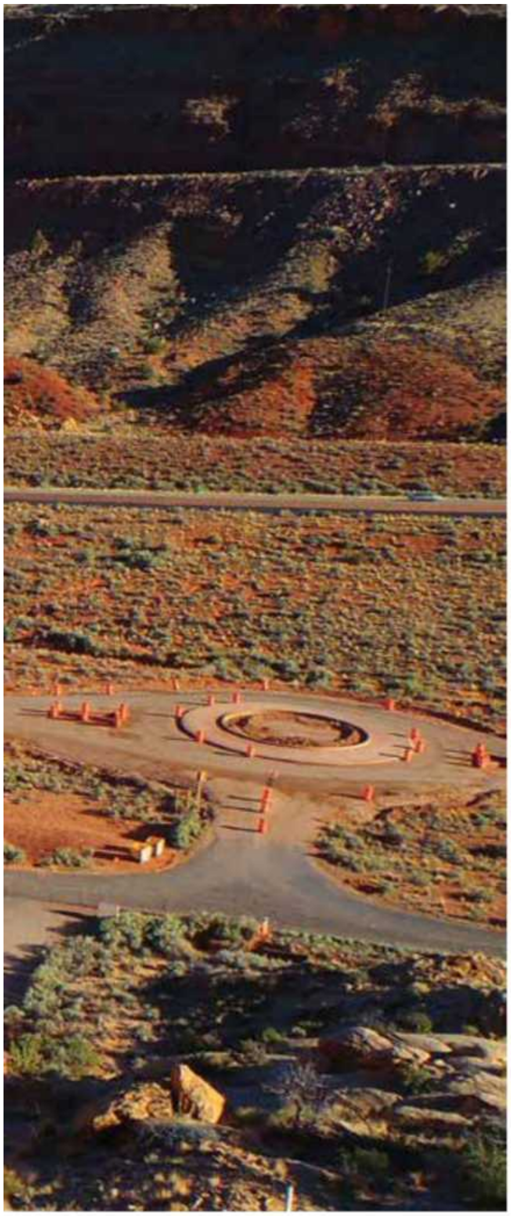
(Above) At the time this aerial photograph was taken in 2017, the roundabout shown here (far right) was under construction in Arches National Park in Utah.

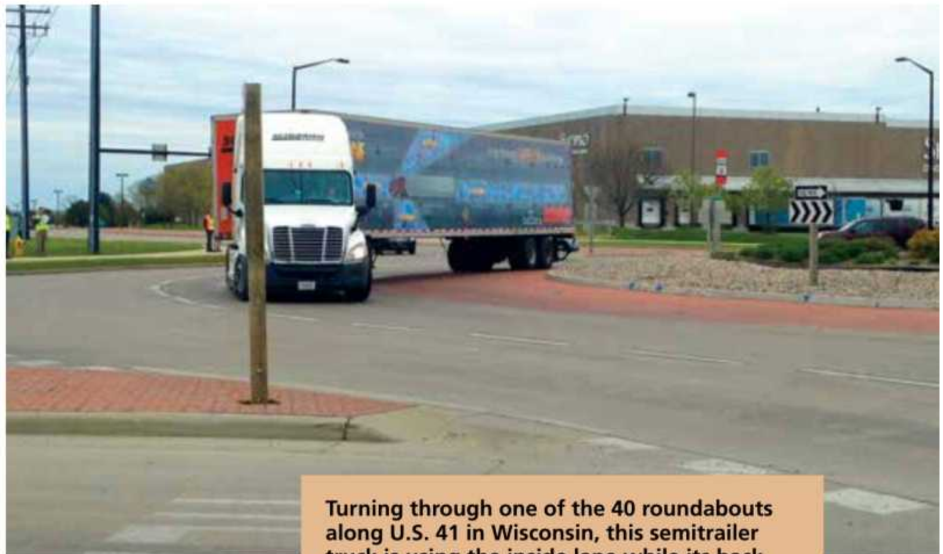
The occasion passed this year without note—most people being unaware—and probably the dozens of high-profile stories about infrastructure funding and autonomous vehicles would have eclipsed the event anyway. Despite the lack of fanfare, however, roundabouts in the United States recently experienced a twentieth anniversary, more or less.

Although there is no exact date to pinpoint, national efforts to establish modern roundabouts as an accepted intersection design can be traced back about 20 years. As documented in the National Cooperative Highway Research Program (NCHRP) Synthesis 488 *Roundabout Practices*, over the course of the past two decades or more, roundabouts have grown from a few sprinkled around the United States to several thousand—with at least one in every State, and some with hundreds.

Experts in the field estimate that the United States now has nearly 4,500 modern roundabouts, meaning the number has nearly doubled over the past 10 years. Compared to countries such as France or the United Kingdom, on the basis of roundabouts to population rate, the United States is still lagging.

Nevertheless, several recently achieved milestones bode well for closing the gap with the Nation's international peers. In 2016, Carmel, IN, constructed the city's 100th roundabout. The Wisconsin Department of





Turning through one of the 40 roundabouts along U.S. 41 in Wisconsin, this semitrailer truck is using the inside lane while its back wheels traverse the raised truck apron.

Transportation finished constructing the first pair of roundabouts with three lanes circulating at the U.S. 41 and WIS 29 interchange in Green Bay and a total of 40 roundabouts along the U.S. 41 corridor in the State's northeastern region. And in 2017, Yosemite National Park in California and Arches National Park in Utah are constructing the third and fourth roundabouts, respectively, within the National Park Service's roadway network.

"Equally notable is that roundabouts are now widely accepted as more than just a solution for traffic safety, but also for their potential as a proven solution for congestion relief and management," says Rob Ritter, acting director of safety design for the Federal Highway Administration. "They're also accepted as a keystone of community walking and biking efforts, and as a catalyst for establishing policies for selecting types of intersections predicated on performance-based metrics and outcomes."

The long-term progress has been slow but steady. It now shows signs of accelerating, thanks to persistence and perseverance by the practitioners on the front lines.

These are their stories.

Stories from the Field

Where a State or local agency introduces roundabouts for the first time, regardless of motivation, controversy is almost sure to follow. After all, even if roundabouts are familiar to the intersection designer or traffic engineer, they may still be new in a given community. That they are circular instead of orthogonal (right-angle), and rely on yielding instead of binary stop-and-go traffic signals or stop signs, tends to

Roundabouts Articles in PUBLIC ROADS

Over the years, PUBLIC ROADS has tracked the implementation of roundabouts in the United States. The first feature article in 1995 established the early context and predated the *Roundabouts Informational Guide* (FHWA-RD-00-068) published in the year 2000, while subsequent articles focused on lessons learned along the way, including the adaptation of roundabouts to different contexts such as at interchanges, junctions with recreational paths, roadway corridor solutions, and scaled-down versions known as mini-roundabouts.

Caltrans, District 6

This aerial photograph shows a rural roundabout on State Route 145 in Fresno, CA. The roundabout, connecting SR–145 and Jensen Avenue, features high-speed approaches.

make people feel uneasy at first. Another frequent concern that people express when discussing roundabouts is how to choose the right exit to reach their destination.

An agency proposing roundabouts in a community for the first time must be prepared to address these anxieties and other concerns. A number of strategies are available, beyond the typical informational meeting on a project. FHWA documented several approaches in a series of case studies known as the "Roundabouts Outreach and Education Toolbox." The overarching lesson from these case studies is that a proactive and persistent approach is often successful, as seen in the cases below.

California. An example from Fresno County, CA, illustrates a classic case of a roundabout proposed as a spot safety improvement. Over a 3-year period, the intersection of State Route 145 and Jensen Avenue near the city of Kerman experienced 10 broadside crashes. The incidents happened despite SR–145 being only a modestly busy highway with roughly 700 vehicles entering the intersection on weekdays during peak hours.

To reduce the number of crashes resulting in injuries to drivers and occupants, the California Department of Transportation (Caltrans) targeted this intersection for conversion from a stop-controlled intersection to a single-lane roundabout. The analysis conducted by Caltrans District 6 clearly demonstrated that a roundabout was the optimal solution for this intersection, with the potential to greatly enhance safety performance while also satisfying goals for mobility and efficiency.

This segment of SR–145, however, is in a heavily agricultural area of the State, meaning that nearby farmers move large equipment and trucks through the intersection on a regular basis. To help address the concerns of the farming stakeholders, Caltrans District 6 organized what the agency and other jurisdictions call a "roundabout rodeo." The district held the event in a parking lot where the public could drive through a mock roundabout replicating the proposed design of a roughly 150-foot (46-meter)-diameter roundabout. (For a video, see www.youtube.com/watch?v=2h3CirwT9xk).

This proof-of-concept demonstration alleviated most of the concerns of the agriculture and trucking industries, helped the project move forward, and laid the groundwork for future cooperative efforts with industry partners on a statewide scale. Subsequently, Caltrans consulted with the California Farm Bureau Federation and the California Trucking Association to solicit feedback to be incorporated on future roundabout designs across the State. Not only did this project catalyze collaboration between Caltrans and key stakeholders, it ultimately proved successful in its aim to improve safety. In observing the operation of the roundabout since construction was completed in 2014, Caltrans has found that the roundabout has eliminated the broadside and injury crashes experienced in the original intersection.

Georgia. On the Nation's opposite shore, along one of the most congested corridors in the country, the Georgia Department of Transportation (GDOT) built its first interchange with roundabouts in 2016 under a design-build contract. The agency converted conventional

Georgia DOT

This aerial photo shows a diamond interchange in Fulton County, GA, with teardrop-shaped roundabouts at the ramp terminals for I–285 at Riverside Drive in Sandy Springs.

The Washtenaw County Road Commission in Michigan constructed these two mini-roundabouts near each other on Textile Road in Ypsilanti Township.

Google Earth

signalized ramp terminal intersections to single-lane roundabouts at the diamond interchange of I–285 with Riverside Drive in Sandy Springs. GDOT constructed the roundabouts using an innovative design-build method to expedite delivery.

The reasons for choosing roundabouts were twofold, and closely related. At this milepost, I–285 in Fulton County carries approximately 219,000 vehicles per day and Riverside Drive just over 4,000 vehicles daily. The conventional signalized intersections at the interchange experienced both operational and safety issues that needed to be addressed.

On most weekdays at afternoon peak hours, the exit ramp queues would reach the freeway mainline, creating safety concerns. After GDOT converted the two existing signalized ramp terminals to single-lane roundabouts, the afternoon peak delays were significantly reduced. A study done prior to the project estimated delays going from 234 seconds per vehicle (signal) to 23 seconds per vehicle (roundabout) at the eastbound ramp intersection, and from 111 seconds per vehicle (signal) to 12 seconds per vehicle (roundabout) at the westbound ramp intersection. Reducing the chronic intersection congestion has helped to resolve the queuing on the ramps.

The experience at the I–285/Riverside Drive interchange is just Georgia's latest roundabouts-related success. Scott Zehngraff, assistant State traffic engineer at GDOT, continues to look for opportunities where roundabouts can be implemented to improve intersection safety and reduce congestion. He reports that GDOT installed its first roundabout on the State highway system in 2004, added one more in 2007, and were up to five by 2012. This is when the pace really picked up, with 17 more roundabouts completed since 2013 and 16 under construction in 2016–2017.

As Zehngraff explains, "It took us a while to get going, but now that we clearly know the benefits of roundabouts, we are making full use of their demonstrated safety and operational benefits. In the past, we had to work hard to convince local governments that a roundabout is the most appropriate solution for a particular intersection; now, however, we are seeing jurisdictions throughout the State taking the lead in pursuing roundabouts to fix safety and operational issues in their communities."

Michigan. The Washtenaw County Road Commission (WCRC) in Michigan has been constructing roundabouts for several years and recently added mini-roundabouts to its portfolio. The county now has just shy of two dozen roundabouts of varying sizes and lane configurations, and the trend to build roundabouts is expected to continue, even while the approach has evolved.

Mark McCulloch, senior project manager at WCRC, says, "We've had tremendous success with roundabouts in terms of reducing severe crashes and eliminating congestion, but we're always looking for ways to save money and time when delivering our projects. Mini-roundabouts—or as we call them in our area, urban compact roundabouts—have much smaller footprints, so they cost less and have fewer right-of-way impacts, meaning we can build more of them more quickly, providing our communities with the safety and operational benefits sooner."

The multifold success of mini-roundabouts in Washtenaw County—safer, cheaper, sooner—has led the WCRC to emphasize "right-sizing" roundabouts going forward. The goal is to balance the immediate need to improve safety and traffic flow with future capacity demands.

Although the overall experience with roundabouts in Washtenaw County has been quite successful, it has not been without a few bumps along the way. In some instances, nonserious crashes increased after the roundabouts were built. After investigating the underlying causes and realizing it was largely due to driver unfamiliarity, McCulloch recruited Katie Parrish, WCRC communications coordinator, and the two set out to tackle issues related to driver education. They conducted an online survey, leveraged social media to spread the message about roundabouts, and created a public service announcement (PSA) contest involving a local high school.

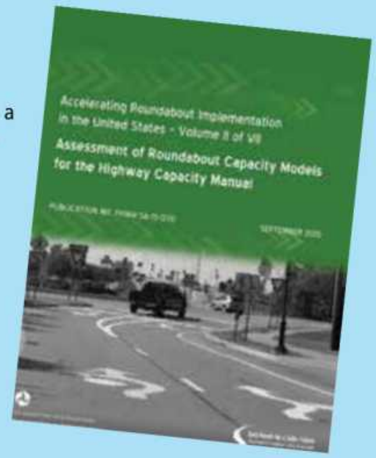
The online survey attracted more than 4,300 respondents and provided valuable insight about how people in the area, including law enforcement, perceived how roundabouts are supposed to work. This insight helped WCRC craft targeted messages when its representatives spoke at public meetings or answered questions in the community.

A social media product is the catchy "Yield Is Your Shield" tagline, which is now a Twitter hashtag (*#yieldisyourshield*) used to spread educational messages about driving through roundabouts.

McCulloch and Parrish are especially proud of the PSA contest held in partnership with Saline High School, which produced a YouTube™ video that has been viewed more than 10,000 times.

Recent FHWA Roundabouts Research

As roundabouts became more common across a range of traffic conditions and locales, various questions emerged on how to tailor certain aspects of their design to better meet the needs of a growing number and diversity of stakeholders. FHWA sponsored a comprehensive evaluation of topics including safety performance, operational efficiency, environmental effects, freight and truck movement, and pedestrian use and accessibility. The seven volumes of reports published under the title *Accelerating Roundabout Implementation in the United States* represent a notable advance in the state of practice of roundabouts.



According to Parrish, "We've developed a multifaceted program to help educate the community on how to properly navigate a roundabout. Our goal is to educate drivers so that we can also eliminate noninjury, nuisance crashes resulting from driver confusion. Roundabouts are too valuable a tool in our toolbox to risk getting a bad reputation from preventable fender-bender collisions."

Washington. The State of Washington has been a leader in roundabouts for more than 15 years, yet many roundabout projects still do not come easily. Even with a culture of safety and thinking outside the box, the Washington State Department of Transportation (WSDOT) finds that continually nurturing innovation and striving for well-rounded performance are still important.

From 2012 to 2016, WSDOT was faced with the challenge of replacing the Evergreen Point floating bridge on SR–520, which connects Seattle with its east side suburbs. The bridge had reached the end of its service life, and along with its replacement came previous commitments to the communities that would be directly affected. Those commitments included improving two nearby partial interchanges and providing connectivity for all modes, including a regional bicycle trail, a transit facility at Yarrow Point, and improved safety and mobility across the board.

The SR–520 project team had been considering roundabout alternatives conceptually but needed to carefully manage the expectations of various stakeholders. Therefore, the team proceeded with caution, engaging with the surrounding communities until the idea gained sufficient traction. Residents of those communities had varying degrees of understanding about how roundabouts work, especially those facilities that would have high pedestrian and bicyclist volumes.

Shown here is a roundabout that WSDOT rebuilt at 84th Avenue and SR–520 on a "lid" over the freeway. The bridge-like roundabout also features pedestrian and bicycle pathways to connect the adjacent Seattle suburbs.

WSDOT Visual Engineering Research Group

5th International Conference on Roundabouts

In May 2017, roundabout experts from around the world convened in Green Bay, WI, as the Transportation Research Board (TRB) hosted the 5th International Conference on Roundabouts. Green Bay is located in the Wisconsin Department of Transportation's (WisDOT's) northeastern region, home to dozens of roundabouts—the largest regional concentration in the State and known for several of Wisconsin's first modern roundabouts in Brown County.

TRB staff and volunteers from the ANB75 Roundabouts Committee collaborated with members of the local event planning committee from WisDOT and the University of Wisconsin Traffic Operations and Safety Laboratory to deliver a stimulating program of podium presentations, poster presentations, and numerous field-based, hands-on learning opportunities and tours at nearby roundabouts.

The International Conference on Roundabouts is held every 3 years and is consistently one of TRB's most popular and successful recurring midyear programs, each time attracting more than 300 researchers and practitioners from the United States and dozens of other countries. In partnership with TRB, FHWA has funded the recording and posting of the proceedings of the roundabouts conferences at http://teachamerica.com/RAB.html to foster continued technology deployment by those unable to travel to the events in person.

Conference attendees, including the bicyclist shown here, participated in one of the meeting's field-based activities—riding bicycles through the roundabout along Lineville Road at its U.S. 41 interchange. The conference organizers made arrangements to bus the group from the convention center to the roundabout, where about two dozen attendees rented bicycles, helmets, and vests that provided them with a "feet-on" learning experience.

As the SR-520 project proceeded, an alternative emerged that involved roundabouts constructed on a bridge structure (referred to locally as a "lid") over a freeway, creating an opportunity for the project team to draw upon internal roundabout resources and expertise in WSDOT.

Brian Walsh, WSDOT traffic design engineer and co-chair of the Transportation Research Board (TRB) Roundabout Committee, has this to say about the project: "The roundabout interchanges provided a better fit with the multimodal goals of the project that will pay dividends into the future for pedestrian and bike connectivity within the communities at these very busy interchanges. Walking through these interchanges is enjoyable, and the roundabouts help create that positive experience."

The roundabouts-based solution succeeded in meeting the expectations of the local stakeholders. They stand today as aesthetically attractive interchanges that feature an extensive network of shared-use recreational paths and open, green space.

What's Ahead for Roundabouts?

At the 5th International Conference on Roundabouts, one of the hot themes was the topic of Intersection Control Evaluation (ICE) policies and procedures. ICE is not a new engineering process per se; rather, it involves establishing a performance-based framework and metrics for assessing intersection types and control alternatives.

At the time of the conference, only five States—California, Indiana, Minnesota, Washington, and Wisconsin—had established ICE policies, but more States reported active efforts to implement or investigate ICE for themselves. Florida, Georgia, Nevada, and Pennsylvania indicated that their ICE policies are expected to be completed by early 2018.

The appeal of ICE is straightforward. States have recognized that ICE can complement performance-based, practical design initiatives and provide an excellent opportunity to bring explicit safety performance into the early stages of intersection decisions. The performance-based approach of ICE goes hand-in-hand with what roundabouts offer, including providing an objective, quantitative basis to inform decisions.

Caltrans Director Malcolm Dougherty notes, "Our primary concern is always with making investment decisions that optimize the safety, health, and mobility of all travelers. The findings generated by our ICE studies have supported the use of roundabouts as a sustainable, cost-effective option to improve air quality and traffic flow. Roundabouts decrease vehicle speed and significantly reduce traffic delays, environmental impacts, and the risk of collisions, as compared to side street stops or signalized intersections."

With thousands of successful roundabouts now in operation across the United States, surely the skeptics are now few in number.

Hillary Isebrands, Ph.D., P.E., is a safety engineer with the FHWA Resource Center, Safety and Design Technical Service Team. She has a B.S., M.S., and Ph.D. in civil engineering from Iowa State University.

Jeffrey Shaw, P.E., is the intersections program manager with the FHWA Office of Safety. He has a B.S. in civil engineering from the Illinois Institute of Technology.

For more information, see http://safety.fhwa.dot.gov/intersection or contact Jeffrey Shaw at 708-283-3524 or jeffrey.shaw@dot.gov.

America's Glory Road

by Richard F. Weingroff

In 1942, 75 years ago, construction crews worked under frigid conditions to complete one of the most challenging engineering projects of World War II. Here's the story of the Alaska Highway.

(Above) Because of the urgency of opening the Alaska Highway for trucks in 1942, most bridges built on the initial "pioneer road" were made from nearby timber. Many of the bridges disappeared over the winter. The report by the Public Roads Administration (FHWA's predecessor) described the fate of a 272-foot (438-kilometer)-long timber bridge with a 10-foot (3-meter) clearance: "The ice at that time was more than 15 feet [5 meters] thick and the bridge had been swallowed up completely." *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

By the time Secretary of State William H. Seward arranged to acquire Alaska from Russia in 1867, the territory's fur trade was no longer profitable, and Russia wanted to end the drain on its treasury. Secretary Seward saw economic opportunities in fish, timber, whales, and, he hoped, gold. President Andrew Johnson signed the treaty on May 28.

Although skeptics at the time referred to the deal as "Seward's Folly," the acquisition was generally seen as advantageous, and more so after gold discoveries began in 1886. Following the transfer, however, Congress took little interest in Alaska, neglecting to pass land laws, fund roads, establish courts, or even provide a means for marriage.

The problem, or one of them, was how to get there.

Getting There

Nearly halfway through the 20th century, a practical land route from the contiguous United States to Alaska did not exist. All transportation was by sea. By the 1940s, an airline had begun operating between Seattle, WA, and Alaska, but the airplanes carried what Alaska's nonvoting delegate to Congress, Anthony J. Dimond,

called "an almost infinitesimal fraction of the transportation service needed for the Territory."

By land, connecting roads from the U.S. border went only as far as Dawson Creek in British Columbia, Canada, about 1,400 miles (2,250 kilometers) short of Big Delta (near modern-day Delta Junction), AK. Canada had not built a connecting road across the rugged topography of its lightly populated northwest. The railroad companies saw no profit in bridging the distance, which was challenging even for the airplanes of the day in the absence of fueling stations. As Dimond explained, Alaska was connected to North America by land, but was "almost as much an island as is Puerto Rico."

Beginning in the 1930s, two presidentially appointed commissions that included Canadian representatives had debated the best route for a road to Alaska. However, neither country was ready to approve a link, in part because the benefits that advocates spoke of did not appear to outweigh the high cost of building and maintaining a road across the rugged frozen terrain of Canada.

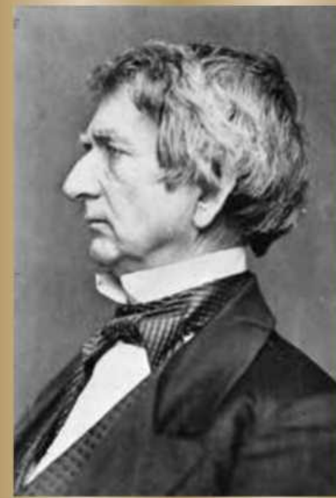
Suddenly a High Priority

Then Japan attacked the United States at Pearl Harbor on December 7, 1941, propelling the country into World War II. Suddenly, a land route to Alaska became a high priority—and the sooner the better. The high priority stemmed from the fact that the Aleutian Islands off southwest Alaska were closer to Japan than was any other point in North America. If the Japanese established forces in Alaska, they would be within bombing range of U.S. cities.

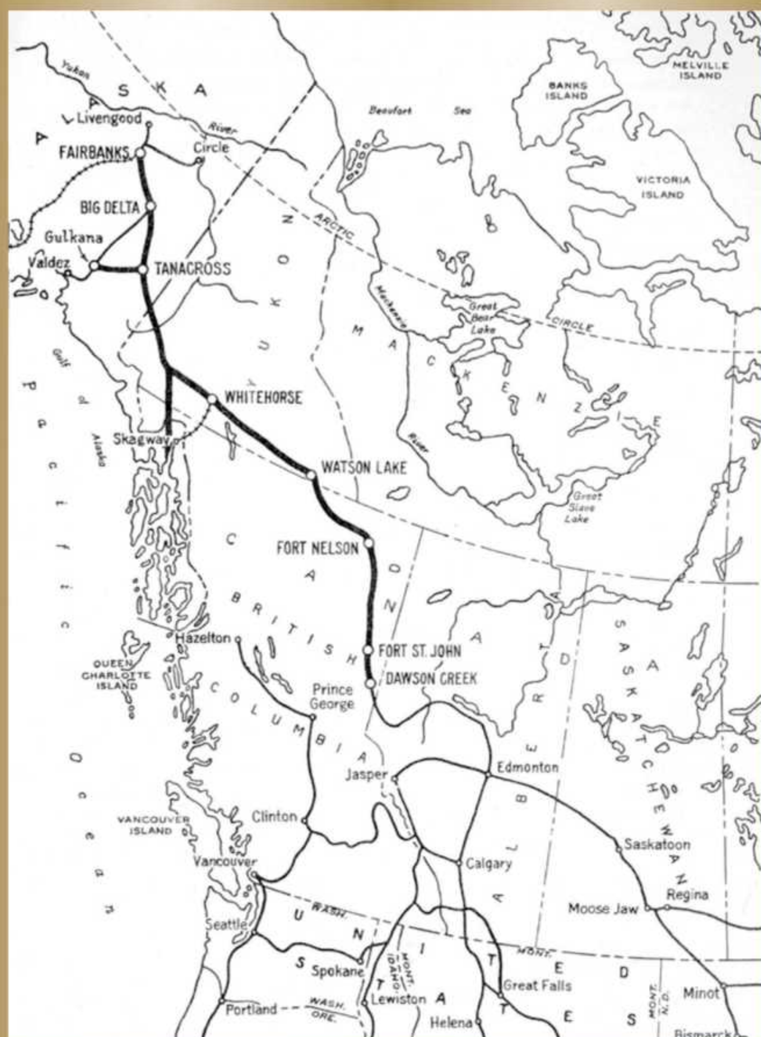
Officials began the perilous task of sending supplies to Alaska by sea and air. According to Heath Twichell's 1992 book *Northwest Epic: The Building of the Alaska Highway*, intelligence reports during the 60 days after Pearl Harbor "listed fifty-eight visual sightings or radio fixes on hostile ships or aircraft" off the West Coast of the United States and the Gulf of Alaska.

A less risky way to Alaska was urgently needed to meet military needs. The solution was a road across Canada to Alaska with a nearby pipeline system, to be known as Canol (short for Canadian American Norman Oil Line or simply Canadian Oil), to service a chain of airfields for refueling along the way. President Franklin D. Roosevelt approved the road project on February 11, 1942, and Canadian officials agreed to U.S. construction across their land on March 18.

Officials considered four routes that had been studied prior to the war before settling on a hybrid course that linked seven airfields



In 1867, Secretary of State William H. Seward (1861–1869) reached agreement with Russia to pay $7.2 million for Alaska, a bargain at 2 cents an acre (less than 1 cent per hectare). *Photo: Library of Congress Prints and Photographs Division.*



This map of the Alaska Highway is from the Public Roads Administration's report on its role in the project.

Before an inspection tour of the Alaska Highway in 1942, Commissioner Thomas H. MacDonald (left) of the PRA met with Joseph S. Bright, the engineer in charge of PRA's work on the project. *Photo: Harold W. Richardson, courtesy of* Engineering-News Record.

built by the United States and Canada in 1941 before Pearl Harbor, with "equipment laboriously brought over frozen winter trails or by river barge and portage during warmer weather," according to Twichell.

The Alaska Highway would stretch northwest from Dawson Creek, where usable roads and rail lines from the south ended, through Fort Nelson and Whitehorse in Canada, and via Tok to Big Delta southeast of Fairbanks, AK. At Big Delta, traffic could use the Richardson Highway to connect with Fairbanks and Alaska's road network.

In this early stage, planners had to take it on faith that they could build the road across the Rocky Mountains between Watson Lake and Whitehorse, where no one had ever seriously considered placing a road, or between Watson Lake and Fort Nelson, where all the details that road builders would need were unknown.

In the interest of speed, officials decided to build the road in two phases. In 1942, the U.S. Army Corps of Engineers would carve a pioneer road out of the difficult terrain as close to the permanent line as possible. Supply trucks would use the pioneer road by year's end. Meanwhile, contractors working for the Public Roads Administration (PRA)—as FHWA's predecessor was called in the 1940s—would follow the troops to begin work on the permanent road. In 1943, with trucks flowing, PRA would complete the permanent road on the best alignment, using as much of the pioneer trail as practical.

(Initially, the project was referred to as the Alcan Highway, but on July 19, 1943, Canada and the United States exchanged diplomatic notes formally naming it the Alaska Highway.)

Getting Underway

By March 1942, the Corps and PRA survey teams were in the wilderness, some traveling on snowshoes or by dog team, while others in airplanes explored mountain passes and river courses. According to a PRA report, "There were mountains everywhere, linked and overladen with illimitable forests. Sprawling river systems, scores of glaciers, vast swamp areas and a multitude of lakes presented problems seldom encountered in a similar undertaking."

Meanwhile, Army engineer troops began arriving. The first, the 35th Engineer Regiment, after an arduous 2,000-mile (3,200-kilometer) trip from Fort Ord, CA, began work on the Alaska Highway on April 11, 1942.

A week later, PRA established a headquarters office in Seattle, WA, on April 20, headed by Joseph S. Bright, to begin assembling contractors. Bright would soon move to Edmonton, Canada, to improve communications with his forces.

PRA rushed a force of 500 engineers and aides into the field for the surveys, while negotiating with four engineering firms to act as project managers. These firms recruited 52 construction contractors who began moving men and materials to the job along three main routes: by rail via Edmonton to Dawson Creek; from Seattle via the inland water route to Skagway, Canada, then on the narrow-gauge railroad to Whitehorse, Canada; and from Seattle by inland water route, across the Gulf of Alaska to Valdez, AK, followed by the Richardson Highway to the job. More than 6,000 civilian workers moved into Alaska. It was, PRA Commissioner Thomas H. MacDonald said, the largest civilian workforce ever to work on a single highway job.

The Black Troops

With so many soldiers needed to fight the war in the European and Pacific theaters of operation, the Army Corps of Engineers needed men. The initial units designated for the Alaska Highway project would not be able to complete the job in the 8 months allotted for the pioneer road before construction would stop with the onset of winter. More units would be needed during those 8 months.

African-American troops were the solution. Since approval of the Selective Training and Service Act of 1940, they had been drafted on the same terms as white troops, but as Twichell explained, "Segregation's

Although much of the Alaska Highway construction occurred during the warmer months, this photograph of one of the first camps to be set up on the project illustrates the challenging conditions. A sawmill supplied building materials and wood for fires. *Photo: Library of Congress Prints and Photographs Division.*

One of many survey crews that decided the routing of the Alaska Highway. *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

legacy of bigotry and prejudice severely limited the possibilities" for the work they would be delegated to do. In general, "black soldiers were assigned to more than their share of units engaged in low-tech, high-sweat duties in the Engineers and Quartermaster Corps." Even in these units, the black soldiers generally had fewer bulldozers and more shovels than white units.

Three black units—the 93rd, 95th, and 97th Engineers, all commanded by white officers—would be shipped to Canada to supplement the white units assigned to the job. (A fourth black unit, the 388th, was assigned to the related Canol pipeline project.) The Corps brought 10,670 men to the job, including 3,695 black troops. Most of the black troops had never been out of the South or experienced snow, much less the severe weather of Alaska. (At the time, they were usually referred to as Negro or colored troops; the term "black," used in this article, came into common use in the 1960s.)

Twichell explained that "Most white officers, especially careerists conscious of the risks to their professional reputation, looked upon duty with black troops as an experience to be avoided if at all possible." They considered the black troops, most educated in segregated Jim Crow schools, to be not just uneducated but "slow learners."

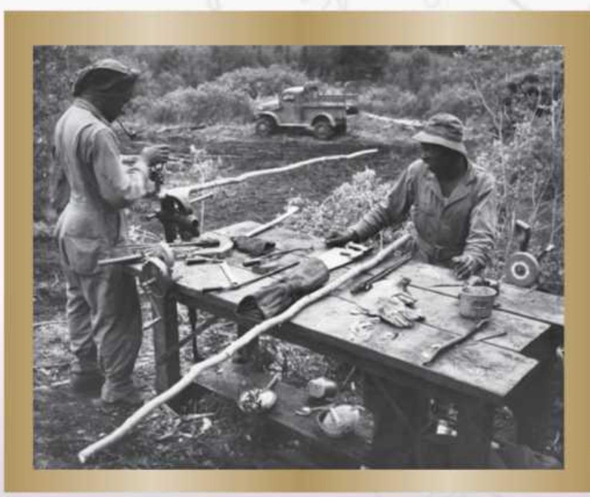
All troops and contractors faced similar problems, including the cold and the ever-present mosquitoes, as well as the unforgiving land. The black troops faced unique problems, such as less desirable equipment and the persistence of segregated latrines that the Army had banned worldwide in October 1942, but that remained in use along the Alaska Highway project. They were a reminder of the separate-but-not-equal conditions the soldiers thought they had left behind when they chose to serve their country.

The 93rd and 95th units worked on the Canadian section of the Alaska Highway. The 97th was the only Corps unit to work on the section in Alaska south to Canada. However, because the route between Big Delta and Tok was near white settlements, the Corps assigned this section to PRA's white contractors. The 97th was assigned to the more isolated section from the small community of Tok to the border.

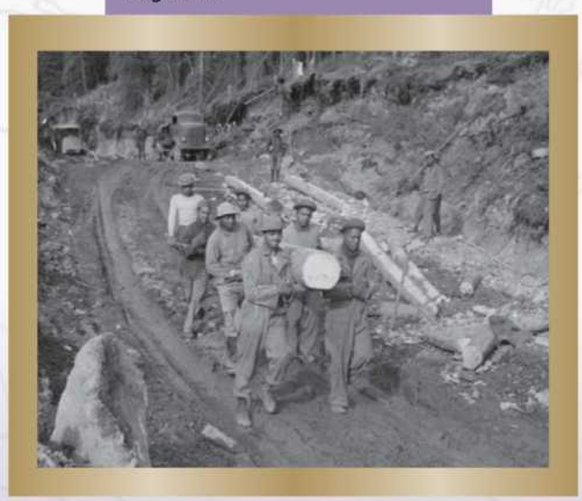
John Virtue, in his 2013 book *The Black Soldiers Who Built the Alaska Highway*, wrote that the 97th had been given "the worst assignment of any of the seven regiments on the highway: the worst weather, the most mountainous terrain and the greatest isolation." First, the 97th had to build a supply road from Slana, AK, 200 miles (322 kilometers) north of Valdez, north to Tok through the rugged Wrangell Mountains.

Progress was slow. Virtue wrote: "The reasons were many: the snow delayed the start of their work; their heavy equipment arrived ten weeks after they did; the terrain was the most challenging of any regiment's." They were delayed by mudslides, washouts, and flooding. "Glacial ice had to be removed by pickaxe or dynamite."

After 2 months, the 97th completed work on the 78-mile (126-kilometer) road north from Slana.



At a workbench, two black soldiers carve branches into poles for use in surveying. *Photo: William E. Griggs, Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*



From John Virtue's *The Black Soldiers Who Built the Alaska Highway*: "Members of the 95th Regiment, who bet white soldiers their paychecks that they could build a bridge across the Sikanni Chief River in fewer than five days, carry logs for the construction." The 95th beat the deadline by a day and a half. *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

The permanent Sikanni Chief River Bridge, midway between Fort St. John and Fort Nelson, represented "spectacular work," according to PRA's report. "Three 140-foot [43-meter] deck trusses were erected. Douglas fir timbers and hardware for the trusses were prepared ready for erection at Vancouver, BC and Portland, OR, and shipped by rail to Dawson Creek." When it opened on April 25, 1943, it was the first large, permanent structure to be completed. It is shown here with the temporary bridge still standing. *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

When they finally reached Tok, the 97th was still "one hundred wooded and swampy miles [161 kilometers] from the Canadian border." With winter not far off, the Corps decided that the 97th in Alaska and the white 18th regiment in Canada would work from opposite directions toward the border to close the gap with a one-lane trail that trucks could use until PRA upgraded it in 1943.

The Japanese Invasion

Meanwhile, fears of a Japanese invasion of Alaska became reality in June 1942, when Japan attacked the Midway Atoll (midway between North America and Asia) and the Aleutians. The Battle of Midway began on June 4, but U.S. forces under Admiral Chester W. Nimitz repelled the Japanese on June 7.

Perhaps to divert attention from Midway, the Japanese had invaded the naval base at Dutch Harbor in the Aleutian Islands on June 3. The Japanese gained control of the mainly uninhabited islands of Kiska and Attu in the Aleutian chain after the only battles of the war fought in North America.

The invasion demonstrated the urgent need for the Alaska Highway. Only 150 miles (240 kilometers) of the pioneer trail had been built by then. If the highway was to serve as a route to rescue China from Japanese control, aid the Soviet Union—an ally in the war—and block Japanese attacks on the 48 States from bases in Alaska, progress would have to accelerate.

(In May 1943, U.S. troops regained Attu Island. In August 1943, American forces discovered that the Japanese had secretly evacuated Kiska Island that month.)

The Pace of Work

The slow progress at the time of the invasion had many causes, including weather, the spring thaw, and the difficulty of getting troops, contractors, and equipment to the site. In May 1942, survey parties were still in the field, with supplies sent to them by canoe, float plane, and packhorse.

By then, the Corps realized that its troops would not be able to clear a path through 1,400 miles (2,250 kilometers) of virgin forest to complete the pioneer trail before winter conditions would shut down operations. To meet its urgent goal, the Corps asked for help from PRA's contractors to open the pioneer trail to trucks on time.

Therefore, in early August, the Corps and PRA abandoned the original division of labor. Instead of focusing on the permanent road, PRA's contractors would now work with the Corps to complete the pioneer trail. Under the new plan, PRA contractors would widen, grade, and surface trails that the Corps had opened.

With PRA contractors and Army engineering units working on segments of the Alaska Highway, gaps began to close. By the end of September, only the most difficult sections, through eastern Alaska and the southwest corner of the Yukon Territory, remained to be completed. The black 97th Engineers completed the one-lane winter trail in Alaska and crossed into the Yukon, while the white 18th, perhaps the fastest of the units, was bogged down in 100 miles (161 kilometers) of permafrost that, according to Virtue's book, "required the time-consuming placement of layers of insulating foliage topped off by logs laid side by side in corduroy fashion."

The final gap was closed on October 25, 1942, south of Lake Kluane in the Yukon. Malcolm MacDonald, British high commissioner to Canada, described the final moments:

"The final meeting between men working from the south and men working from the north was dramatic. They met head on in the forest. Corporal Refines Sims, Jr., a Negro from Philadelphia [of the 97th Engineers] . . . was driving south with a bulldozer when he saw trees starting to topple over on him. Slamming his big vehicle into reverse he backed out just as another bulldozer driven by Private Alfred Jalufka of Kennedy, TX, broke through the underbrush. Jalufka had been forcing his bulldozer through the bush with such

This 1942 photograph shows a stretch of the Alaska Highway. *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

speed that his face was bloody from scratches of overhanging branches and limbs. That historic meeting between a Negro corporal and white private on their respective bulldozers occurred 20 miles [32 kilometers] east of the Alaska-Yukon Boundary at a place called Beaver Creek."

A photographer captured the image of the two men standing on the bulldozers while shaking hands. The photograph would appear in newspapers around the country and remains a staple of books and articles about the Alaska Highway.

The *Atlanta Daily World*, a black newspaper, published an article about the event under the headline: "Reveal Negroes Help Build Alaska Highway." This headline revealed one of the gripes of the black troops in Alaska: They were rarely mentioned in government press releases or news reports.

Lt. Colonel James L. Lewis, the 93rd's white leader, wrote, "Most of the news articles in magazines about the construction of Alaska Military Highway failed to give Negro regiments much credit for their share of the completion of that project. Enlisted men of this regiment feel this deeply and their friends back home ask them why this is true."

On November 20, more than 200 dignitaries, guests, and journalists from the United States and Canada, including PRA Division Engineer Bright, arrived at Soldiers' Summit on the south end of Lake Kluane in the Yukon to mark completion of the pioneer trail. The temperature was -15 degrees Fahrenheit (-26 degrees Celsius), and snow was falling as four soldiers held the red, white, and blue ceremonial ribbon: Corporal Sims and Private Jalufka, who had closed the last gap, and Master-Sergeant Andrew Doyle (white) and Corporal John Reilly (black). Alaska's Secretary of State E. L. "Bob" Bartlett and Canada's Minister of Pensions and National Health Ian MacKenzie used scissors engraved in Alaska gold to cut the ribbon.

As trucks began to roll on the Alaska Highway, winter ended all but maintenance operations on the road.

The Press Reacts

The press recognized the achievement.

It was "America's Burma road," "the new Northwest Passage," a military "life-line," and the "Highway to Russia." Articles called it "Alaska's Short Cut to Tokyo," a "Six-Month's Miracle" of "modern engineering and human tenacity," "One of the Greatest Road-Building Jobs of Our Day," and "one of the biggest and toughest jobs . . . since they built the Panama Canal." It was "an Army triumph" that created "a dagger aimed at the heart of Japan, a helping hand outstretched toward Siberia in case of a Japanese attack on Russia, a bulwark against a Japanese offensive on the North American continent."

Much of the Alaska Highway was graded, as in this section of the road, then paved with gravel. *Photo: Library of Congress Prints and Photographs Division.*

On October 25, 1942, a bulldozer driven by Corporal Refines Sims, Jr., an African American, and one driven by Private Alfred Jalufka, a white soldier, broke through the forest from opposite directions near Beaver Creek, closing the last gap in the Alaska Highway. This photograph, taken by Harold W. Richardson of *Engineering News-Record*, was widely reprinted in newspapers and magazines at the time. *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

Engineering News-Record began a three-part series in December 1942 on "Alcan—America's Glory Road." Only last spring, the author wrote, experts said the highway "could never be built in time to be of use in this war." They failed to understand "the fortitude of men—officers and soldiers, engineers and contractors—and the stamina of American construction equipment that built 1,636 miles [2,633 kilometers] of new route and rebuilt 162 more miles [261 kilometers] of old trail, all in one short construction season."

National Geographic covered what it referred to as "an Engineering Epic." The builders faced unusual obstacles such as mosquitoes, mud that swallowed even tractors, swirling dust, "jellylike muskeg," and "ravenous gnats." The article noted, "Black men and white have cursed the country in a score of American dialects, and many have remarked at one time or another that if the Japs conquered the country it would only serve them right." The "ingenuity, the morale, and the toughness" of the men who built the Alaska Highway should reassure Americans that the inevitable confusion at the start of the war would "speedily give way to efficiency and to a successful outcome of the war."

Finishing the Alaska Highway

The plan had been for PRA to design a road to standards for park and mountain roads—a well-drained, stabilized roadbed with an overall width of 36 feet (11 meters) to allow

At Soldiers' Summit on the south end of Lake Kluane, officials from the Corps, PRA, the United States, and Canada met on November 20, 1942, in frigid conditions to celebrate the opening of the pioneer truck route of the Alaska Highway, with speeches and a ribbon cutting. *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

for two 12-foot (3.7-meter) surfaced lanes, 3-degree curves in prairie terrain and 16- to 19-degree curves in mountain sections, with maximum 5-percent grades in the lower levels and 7 percent in the mountains. The surface was to be 18 inches (46 centimeters) of gravel or rock.

The rush to complete a truck road in 1942 resulted in the road being too narrow, not well surfaced, and containing many wooden bridges that did not survive the winter. Truck traffic after the opening ceremonies was limited. The section around Nisutlin Bay was nearly impassable until the ground froze, while the 400-mile (644-kilometer) section across the Rockies from Summit Lake to Teslin included steep grades, narrow widths, and sharp curves.

PRA sent surveying parties to decide the best location for the permanent highway. They completed most of their work in December 1942, but a few crews continued field operations through midwinter despite temperatures as low as -40 degrees Fahrenheit (-40 degrees Celsius). In general, the crews identified locations with long sight distances, easy curves, and gentle grades.

By the time the 1943 construction season began, PRA had its contractors ready, but initially they made slow, unsatisfactory progress because of rain, mud, frozen ground, a shortage of equipment and repair parts, washed-out temporary bridges, and bottlenecks at river crossings. In July, with these problems behind them, the contractors were ready for the hard work ahead, but as PRA's annual report put it, "And then nature delivered the most serious blow since the beginning of construction." A "tremendous downpour of rain" on July 9 and 10 took out many of the temporary bridges and washed out long sections of the pioneer road. The contractors had reopened the pioneer road by July 20.

The contractors kept the pioneer trail in service while building the permanent road, much of it on new locations. By mid-July 1943, 81 contractors were on the job, employing about 14,000 civilian workmen operating 6,000 units of heavy equipment, including scrapers, power shovels, elevating graders, trucks, motor graders, gravel plants, and sawmills. About 1,850 PRA employees were on hand. Working two shifts of 10 hours each day, PRA and its contractors completed the major portion of the work between mid-July and the end of October.

The Alaska Highway crossed only three major rivers: the Peace, Liard, and Tanana. However, the total length included 133 bridges of 20 feet (6 meters) or more in length, of which 64 were more than 100 feet (30 meters) long, while 69 ranged between 20 and 100 feet (6 and 30 meters). Many presented unique problems because they would have to be designed to survive icy conditions during the winter and spring. When work ceased on October 31, 1943, PRA had completed 99 bridges, while 34 were incomplete

After the opening ceremonies, this weapons carrier led a convoy to Fairbanks, 460 miles (740 kilometers) and 24 hours away. As shown by the signs on the front, the truck also had been the first to drive from Dawson Creek to Whitehorse. *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

or had not been started due to late approvals by the Army Corps.

Even with work remaining on the permanent bridges, the highway was passable for its entire length. On October 31, PRA turned the Alaska Highway over to the Corps to maintain for the duration of the war. The Corps also took over remaining contracts.

Twichell summarized PRA's contribution: "Of the 1,420 miles [2,280 kilometers] of highway across Canada to Alaska that were opened to the public after World War II, about two-thirds (970 miles [1,560 kilometers]) consisted of the original Army pioneer road, all of which had been substantially improved and upgraded by the PRA. Another 450 miles [720 kilometers] of the highway were new—and strictly PRA-built. Here the Army's pioneer road had served its original purpose as an access route and was abandoned thereafter. The wartime cost of the Alaska Highway came to a seemingly modest $138 million—less than $100,000 per mile."

The Post-War Highway

In 1944, the Corps turned over maintenance of the Alaskan portion of the highway to the territorial Alaska Road Commission, but maintained the Canadian portion until April 1, 1946. On that date, dignitaries gathered in Whitehorse to celebrate transfer of the Canadian portion to Canada.

Professor Ken Coates, in *North to Alaska!* (1992), described the ceremony as "decidedly less electric" than the November 1942 celebration of the completed pioneer trail, but "the appropriate pomp and circumstance" occurred.

Ceremony aside, one of the Canadian engineers summarized what had just happened: "We took over a strange unknown ribbon of road covered with snow." The Corps left behind vehicles and equipment that "needed immediate replacement." Given the state of the equipment, the task of maintaining and repairing the road "looked hopeless."

The drive along the Alaska Highway was sufficiently rugged that travelers needed to obtain a permit. With accommodations widely spaced, each vehicle had to have enough gas to reach the next service station, as well as spare tires, an axe and shovel, sleeping bags, and proper clothing in case of breakdowns.

During these early years, the trip was not for tourists. In June 1946, the traffic control board in Edmonton approved 616 permits for "essential travel," but refused two to three times more applications by sightseers. A year later, officials warned that that they would not issue permits "to those who wish to travel on the highway for a holiday."

"Almost imperceptibly," Coates wrote, "a new society emerged along the Alaska Highway," as accommodations, even small communities, grew. The road, built in haste and little improved during the war, "was interminably long, excruciatingly dusty at times, rough and ragged." He quoted a traveler in 1947 who observed, "The highway is literally covered at the side with signposts: Slow – Steep Hill – Winding Road – Turn – Dumps – Danger – Falling Rocks – Slow – Washout – Detour."

Still, the Alaska Highway had its compensations. Coates wrote: "The scenery never stopped: the grand vistas from Steamboat Mountain, the river scenes along the Liard, the rocky hillsides along Muncho Lake, the stunning beauty of Teslin and Marsh lakes, the breath-taking landscape portrait that filled the windshield on approach to Haines Junction, the chilling blues of Kluane Lake, the marshy tracks south of Northway, the broad views of the Tanana Valley were almost too much to absorb."

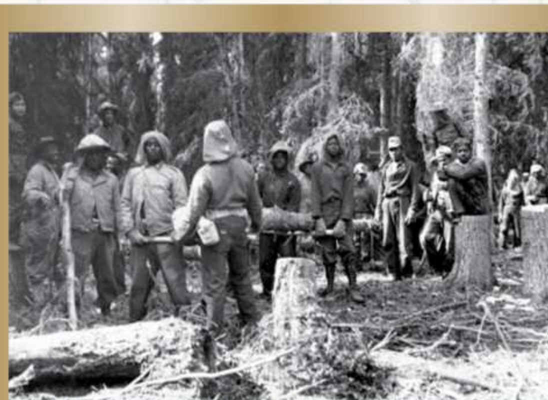
The Alaska Highway, Coates concluded, "did not impress many travelers in the years between 1946 and 1964—except for those who noted its ruggedness, propensity toward dust, and its twisty, seemingly illogical course." In the early 1960s, officials in Alaska, which became a State in 1959, and Canada began thinking about the future of the Alaska Highway.

Shakwak

On April 1, 1964, Canada's Department of National Defence transferred the Alaska Highway to the Department of Public Works, the highway agency. Although reconstruction of the highway and its paving seemed inevitable, the fact was that more Americans than Canadians used the highway. Canada stretched out the paving of its section over the years, with a focus on improvements in the more populated area from Whitehorse south.

Alaska had paved its section of the Alaska Highway by the early 1960s, but the sub-Arctic climate took its toll on the asphalt surface. One traveler wrote, "We found this 'paved' stretch so wrenched by frost-heaves, so full of sharp chuckholes that, despite its lack of dust, it offered no more comfortable or rapid travel than the gravel." By the 1980s, Coates wrote, after repaving, "the Alaskan portion of the highway was in first-rate condition, matching southern highways of similar size and importance."

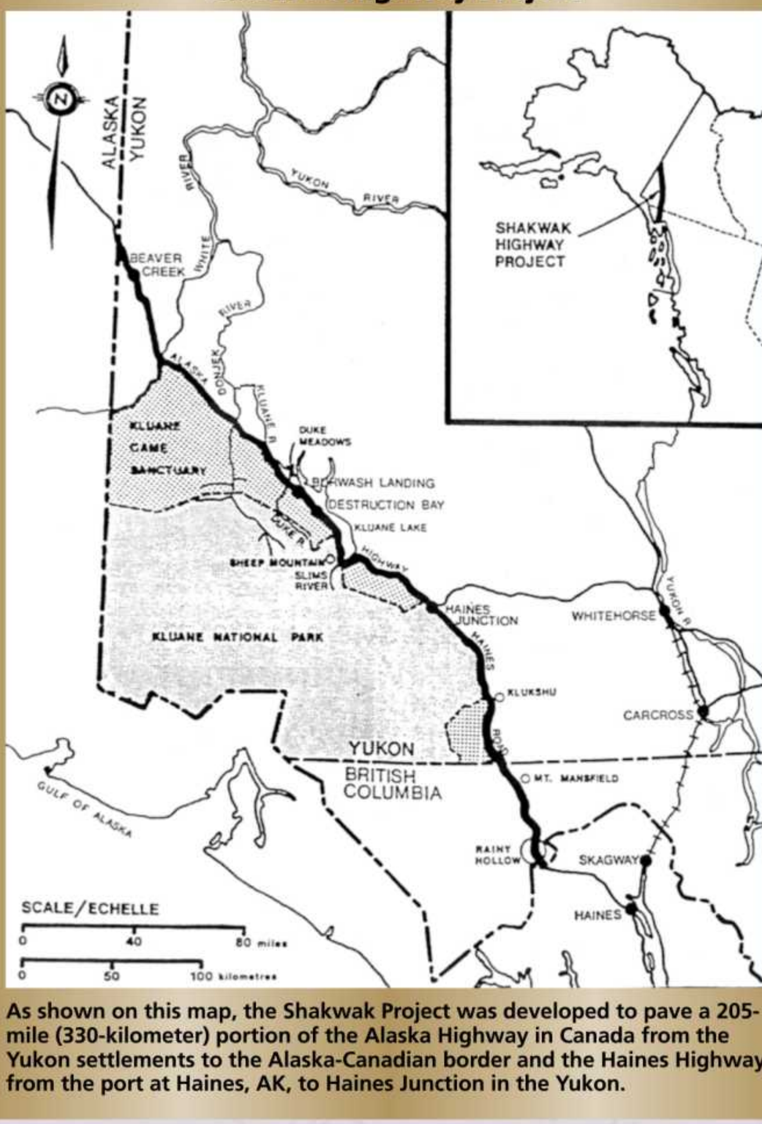
In the early 1970s, U.S. and Canadian officials began discussing a plan to pave a 205-mile (330-kilometer) portion of the Alaska Highway from the Yukon settlements to the Alaska-Canadian border, as well as the Haines Highway from the port at Haines in Alaska to Haines Junction in the Yukon. At the time, the Haines Highway, sometimes called the Haines Cutoff, was the only direct



According to author Heath Twichell, black troops on the Alaska Highway project were more likely to be "engaged in low-tech, high-sweat duties" than their white counterparts. Clearing the forest to make way for the highway was a typical low-tech job. *Photo: Courtesy of Office of History, Headquarters, U.S. Army Corps of Engineers.*

The U.S. and Canada approved the Shakwak Project to improve the Alaska Highway from the Alaska border to Haines Junction in Yukon Territory and from there a portion of the Haines Highway, the only land link to southeastern Alaska. On August 15, 1978, officials gathered for the groundbreaking ceremonies at Haines Junction. In the lead is FHWA's Region 10 Administrator Louis E. Lybecker (holding a sledgehammer), followed by FHWA Associate Administrator for Engineering and Traffic Operations Harry A. Lindberg.

Shakwak Highway Project



As shown on this map, the Shakwak Project was developed to pave a 205-mile (330-kilometer) portion of the Alaska Highway in Canada from the Yukon settlements to the Alaska-Canadian border and the Haines Highway from the port at Haines, AK, to Haines Junction in the Yukon.

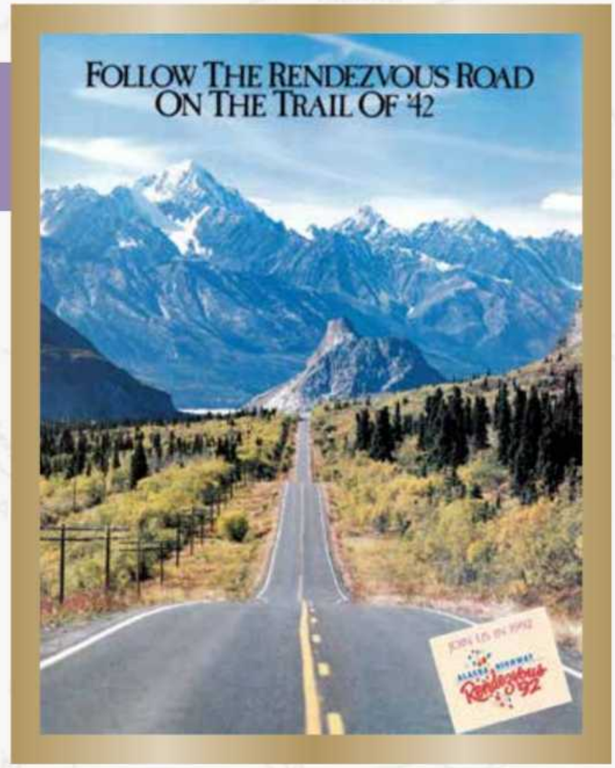
land link between Fairbanks and the population centers in southeast Alaska. The Corps had built the highway in 1943, partly as a route for getting supplies to the Alaska Highway.

In February 1977, the two countries signed an agreement providing for U.S. funding for reconstruction in return for Canadian engineering, resources, and a commitment to maintain the road in Canada. The work was called the Shakwak Project, named after a valley in the Yukon. Following an environmental review, officials held a groundbreaking ceremony on August 15, 1978, at Haines Junction.

Today, the Alaska Highway and the Haines Highway are paved except for a section of bituminous surface treatment on the Alaska Highway near the Alaska/Canada border at Beaver Creek. This section has not been paved due to permafrost challenges.

The Story They Forgot To Tell

According to historian Douglas Brinkley, the Alaska Highway was "not only the greatest engineering feat of the Second World War; it is a triumph over racism." He explained: "When [Corporal] Refines Sims, Jr., a bulldozer technician with the 97th Engineers, converged with Private Alfred Jalufka, lead driver of the white 18th Engineers, on 25 October 1942, a major construction gap was closed. But the symbolism was even greater: blacks and whites working together for a common cause. Before long the U.S.



For the road's 50th anniversary, brochures invited visitors to celebrate the Alaska Highway. Much of the celebration neglected the black troops who made a major contribution to construction of the pioneer truck road in 1942.

Army would become integrated [by President Harry S. Truman's Executive Order 9981 on July 26, 1948], a major step in the African American struggle for racial equality."

Many years after the war, the black soldiers who helped build the pioneer trail received recognition for their accomplishment, largely thanks to Professor Lael Morgan of the University of Alaska-Fairbanks. As she researched a planned article on the highway, she became fascinated by the black regiments. The Army, she found, did not have troop lists or regimental directories. Histories of the project barely mentioned them. They had never held a reunion. She told a reporter in 1990, "You go through all the souvenir books of the Alaska Highway and all the old news clippings, you never see a single black face. Nor did any historian know the whereabouts of these people. So I started looking."

Initially, she said, she was told she would search in vain "because black men don't live as long as white men." In cooperation with author Heath Twichell and James Eaton of the Black Archives Research Center and Museum at Florida A&M University, she located 70 veterans. An article by Professor Morgan was the cover story in an August 1992 issue of *Anchorage Daily News Magazine*, with the cover calling it "The Story They Forgot to Tell: How Black Soldiers Overcame Racism to Build the Alaska Highway."

In 1992, most of the celebrations of the 50th anniversary of the Alaska Highway's pioneer trail neglected the black soldiers. They were, in Eaton's words, "A lost page in history."

However, Morgan's efforts had prompted interest in the subject. On July 4, 1992, the city of Anchorage invited several of the former black troops to participate in the city's parade.

Two of them, Albert E. France and Donald W. Nolan, Sr., were retirees from Baltimore. Ann LoLordo of *The Baltimore Sun* interviewed them. They both recalled the cold. France said, "It was awful cold and it snowed for days." Nolan added, "We'd take galoshes, rubber galoshes—we called them 'Arctics'—and we'd wear three, four pairs of socks. We would double up on pants. We slept on the ground in pup tents."

Food was never plentiful, especially when the climate cut off supply routes. Nolan recalled, "We'd kill a bear, a huge black bear . . . and those chops were delicious." Snow was bad enough, but in the summer, LoLordo wrote of their recollections, "The rains started and the rivers swelled. In summer, mosquitoes droned like airplanes and the 'muskeg,' a uniquely Alaskan bog, swallowed tractors."

Looking back, Nolan said he was glad to have served on the project. "You have something to tell your kids."

Remembering the Alaska Highway

A 2011 guide to the Alaska Highway called it "the last great overland adventure left in North America." The road "provides a path to some of the most thrilling outdoor recreation opportunities in North America." The guide recommended good tires "to absorb some of the strain imposed by errant driving or less-than-efficient road crews," and "a complete tune-up done by a competent mechanic." Travelers should "carry a basic set" of tools "for minor repairs at roadside."

The Alaska Highway, the author stated, "leads you back in time." The author was referring to "a simpler place, a wilder place, and, to some, a more enchanting time." That may be, but nothing about its construction was simple. The Alaska Highway was built in the desperation of war, at a time when the outcome of that war could not be known, by men stressed to their limit by the challenges of an unforgiving environment. It was built in part by black soldiers who faced the same challenges common to all workers on the project, but also the prejudices of the day, their role little known during the project, and forgotten for decades.

Today, 75 years later, the Alaska Highway remains a tribute to the soldiers, white and black, and civilians who overcame multiple challenges to build it. It also is a reminder of a bygone era that feels alien to our lives in the 21st century, but that must not be forgotten.

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Focus on Freight: Article 3

Delivering the Goods

by Tamiko Burnell, Antonio Santalucia, and Alexander Epstein

USDOT and its partners are working to improve the movement of freight in growing urban areas across the country.

(Above) Cities face the ongoing challenge of accommodating increasing freight traffic on the same routes with other modes of travel. Here, a bicyclist is using a dedicated bike lane along a roadway heavily used by trucks in Seattle, WA. *Photo: Chris Eaves, Seattle DOT.*

Four out of five Americans live and work in metropolitan areas. Therefore, while freight mobility is a national challenge, the flow of freight to, within, and from cities is critical to modern society. By 2045, the U.S. economy is expected to increase by about 80 percent, and the Nation's population is projected to increase by more than 20 percent to about 390 million people.

To support the projected growth in population and economic output, freight tonnage across all modes is expected to increase by roughly 50 percent by the year 2040, or more than double the projected rate of population growth. This growth in overall freight demand will put increased pressure on transportation infrastructure throughout the country, but it will have a disproportionate impact on metropolitan areas, where most of the population growth is expected to occur.

Fortunately, to facilitate the movement of goods in cities, a range of strategies is available for State and local transportation agencies to implement, in coordination with private-sector freight shippers, carriers, and logistics providers.

The terms city, urban, and metropolitan can have specific meanings when used by USDOT, the Census Bureau, and other agencies. Here these terms are used interchangeably to refer to densely settled areas where freight pickups and deliveries are more likely to affect other roadway users.

The U.S. Department of Transportation is working with its partners across the country and around the globe to identify, promote, and implement effective strategies to facilitate urban freight flows.

Importance of Urban Goods Movement

The efficient movement of goods is a crucial foundation for the Nation's modern economy. However, vehicles carrying goods in an urban environment must share the transportation network with travel by pedestrians, bicyclists, buses, and passenger vehicles. In addition, freight vehicles, even those traveling around or through a city to reach another destination, can be affected by or contribute to the same congestion that delays other urban travelers.

Many of the country's primary gateways for international trade are located in metropolitan areas, increasing the challenge of managing reliable and efficient freight movements. Fourteen of the country's 25 most populous metropolitan areas are home to a major trade gateway, typically a marine port or airport. The carriers moving freight to and from these gateways must contend with the congestion in these areas—while contributing to that same congestion.

Urban areas also face new challenges from the rapid growth of e-commerce. Each year, an increasing amount of freight is delivered directly to individuals at home or work rather than to retail stores, resulting in changes to truck volumes and travel patterns. This trend is rippling through the freight industry. For example, the total shipping/package volume of the U.S. Postal Service has increased from 3.3 billion pieces in 2011 to 4.5 billion in 2015. In addition, retailers are building more distribution and fulfillment centers in or near urban areas to respond to growth in expedited deliveries (such as same-day or next-day deliveries).

"Freight trips are rising steadily as online shopping grows," says Michael Replogle, deputy commissioner for policy at the New York City Department of Transportation. "The number of deliveries to residences is up 30 percent in just 5 years."

Addressing the Challenges

In coordination with private sector partners, State and local transportation agencies can implement strategies to facilitate the movement of freight in metropolitan areas and reduce its impacts on urban residents and other travelers. These strategies range widely, from stakeholder engagement to zoning and land-use decisions to parking enforcement. Agencies may consider strategies in such disciplines as operations and logistics, safety, and environment and livability.

Operations and Logistics Strategies

Moving freight by truck can lead to increased roadway congestion in certain areas of a city and at certain hours of the day. To address these types of issues, State and local transportation professionals can work with private carriers to implement operations- and logistics-oriented approaches, such as those that seek to reduce the number of truck trips, shift them to offpeak hours, or otherwise minimize their impacts on traffic flow.

Operations strategies include actions by public agencies to facilitate first- and last-mile goods movement in urban areas. These tactics involve making changes to how freight transportation uses public roadways, such as designating truck routes and establishing curbside loading zones. Logistics strategies involve changes in the practices of freight carriers, shippers, and receivers that provide public benefits, such as reduced congestion or emissions. What follows are descriptions of some operations- and logistics-oriented approaches.

Growth in e-commerce has led to increased volumes of freight deliveries to residences. This parcel delivery truck is parked on a sidewalk in New York City while delivering packages to an apartment building. *Photo: Alison Conway, City University of New York.*

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Competing uses of curbsides, including space for loading and unloading of freight vehicles, is a common issue during deliveries. Here, a truck passes a curbside space dedicated to bicycle parking (in the blue rack) in Portland, OR.

Loading Zone Management

One of the many challenges faced by truck drivers making first- and last-mile freight movements in cities is the scarcity of available loading areas (both onstreet and offstreet). In metropolitan areas, the competition for curb space is usually intense, particularly in commercial districts. In addition, zoning requirements might not call for builders to include adequate offstreet loading areas, buildings may predate such zoning requirements, or carriers might not want to use the offstreet space provided if it increases the amount of time they have to spend per delivery. Any of these issues can affect the demand for curbside space.

When there is not an adequate supply of loading zone spaces or the spaces provided are considered inconvenient by carriers, freight drivers often create their own parking solutions. Methods such as double-parking by delivery vehicles can reduce traffic flow and exacerbate traffic congestion. These methods also can create safety risks. These problems can be particularly acute at urban locations that generate a high amount of both freight and pedestrian traffic.

As part of an overall strategy to manage curbside loading areas, public agencies can consider increasing the supply of loading zone space and improving the enforcement of curbside signage and regulations. Cities also can balance the demand for use of curbside lanes by dedicating lanes for different uses at various times of the day.

Transportation and planning agencies should collect data on the specific needs of an area. Changes to loading zone policies and locations are more effective when they are based on surveys of curb use and information from nearby freight receivers.

In addition to increasing loading zone supply, public agencies can also consider managing demand, such as by using metered loading zones. For example, since 2015, the District Department of Transportation in Washington, DC, has required commercial vehicles to pay for the use of loading zones. To park in a loading zone, a commercial vehicle operator must either display a daily or annual permit on the vehicle, or pay using a phone-based application immediately after parking. The metering program also generates valuable data for the department on the demand for loading zones in different parts of the city and at various times of the day.

"Curbside space is a finite resource and demand for it only continues to increase," says Laura Richards, a transportation planner with the District Department of Transportation. "Understanding loading demand and carrier behavior and making informed policy and

Researchers around the world are testing ways of enabling more urban receivers to accept deliveries during off-peak hours. *Photo: Chris Eaves, Seattle DOT.*

curbside decisions has implications for congestion and safety as well as curbside and loading space."

Alternative Times And Locations

By changing when or where deliveries occur, shippers can minimize some of the impacts of freight traffic.

Off-Hour Delivery. Voluntary off-hour delivery programs aim to reduce congestion and pollution from truck traffic by encouraging urban receivers—sometimes with financial incentives—to shift daytime deliveries to offpeak or "off" hours (roughly 7 p.m. to 6 a.m.). This type of program can be an appropriate strategy for urban areas, such as downtown commercial districts, with high levels of truck traffic and roadway congestion.

Off-hour delivery is an active area of study. In the United States, the Federal Highway Administration has funded several research projects and pilot tests in New York City; Orlando and Pensacola, FL; and Washington, DC. Several cities abroad, including Copenhagen, Denmark; Sao Paulo, Brazil; and Stockholm, Sweden, have also conducted pilot tests to analyze the potential benefits of off-hour delivery.

Alternative Pickup and Delivery Locations. When recipients are not home to receive packages, carriers must make return trips, increasing the cost of delivery. Dropping off packages at an alternative location can reduce truck traffic and delivery costs for carriers, while providing convenience for consumers. Ideally, the availability of these alternative locations also reduces vehicle miles traveled to some degree, thus alleviating congestion and reducing emissions.

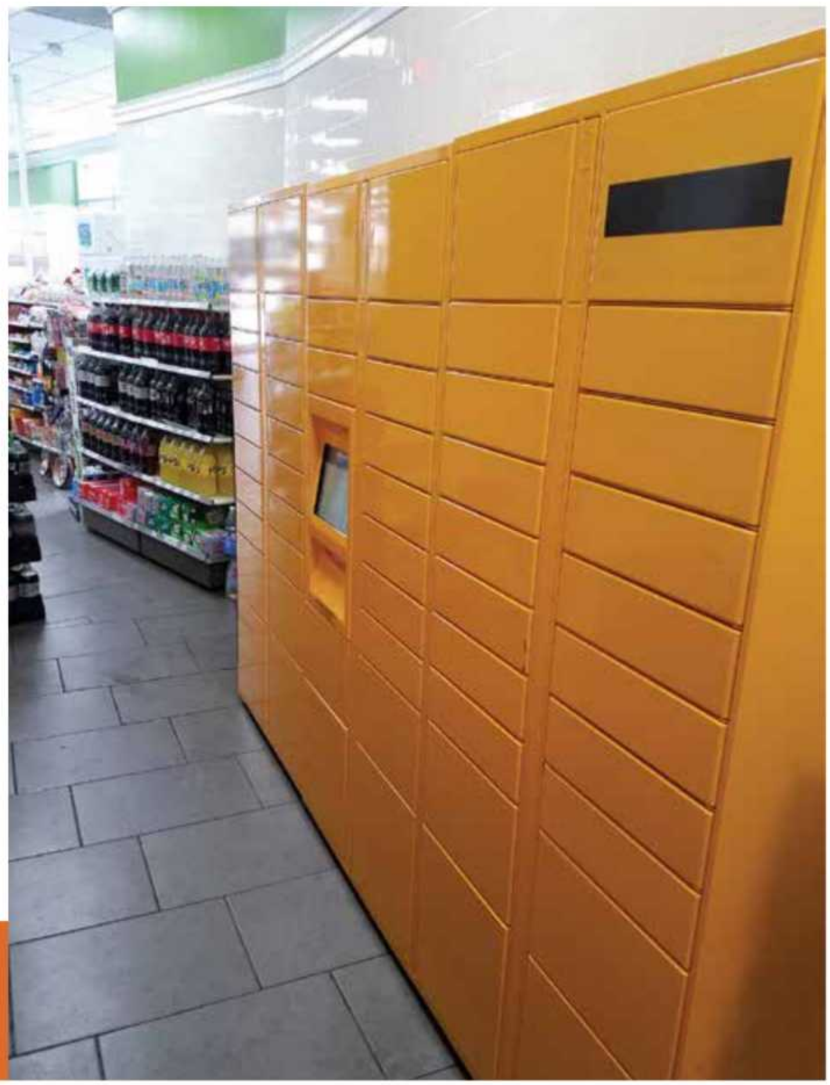
Alternative locations can be neighborhood businesses with extended hours (such as convenience stores), or unstaffed parcel lockers located outdoors, in public facilities (such as train stations), or near accessible neighborhood businesses. Some carriers and online retailers

New York City's Off-Hour Delivery Program

New York City has implemented a program to encourage shifting freight deliveries to the overnight, offpeak hours. After a successful pilot phase with about 30 receivers concluded in 2010, FHWA sponsored an implementation phase that ran from 2011 to 2013. Researchers estimated that during the second phase, more than 400 businesses across Midtown and Lower Manhattan shifted portions of their deliveries to off hours. The New York City Department of Transportation (NYCDOT) is actively seeking additional carriers and receivers that are interested in pursuing off-hour deliveries.

In the pilot phase, half the participating establishments used staffed off-hour deliveries while the other half used unassisted off-hour deliveries. At the end of the pilot, all the receivers maintaining staffed deliveries reverted to daytime deliveries. In contrast, almost all of the receivers that used unassisted deliveries during the pilot test continued doing so after the pilot ended. Interviews revealed that these receivers stayed with unassisted off-hour delivery because of the superior reliability in delivery times, which enabled them to reduce their inventory stocks.

NYCDOT estimates that because of the implementation phase, 40 to 50 daily delivery tours in Manhattan have switched to offpeak hours, for a total carrier savings of more than $2.25 million annually. Researchers for the program estimated that more than 20 percent of Manhattan's truck traffic could be shifted to offpeak hours, and that a shift of that magnitude would generate economic benefits of $150 million to $200 million in travel time savings and productivity increases.



Freight carriers and retailers have begun installing parcel lockers in private establishments, such as this one in a convenience store, and in public locations.

By locating the Sunset Park Material Recovery Facility, shown here, at a marine terminal in Brooklyn, New York City shifted some shipments of recycled materials from trucks to barges. *Photo: John Majors, Aerial & Architectural Photos of NJ.*

already have installed parcel lockers in such locations. Public agencies can work with carriers and facility owners to encourage the placement of parcel lockers in places that are likely to reduce vehicle trips or vehicle miles traveled.

Changes at Urban Ports

Gate hours for marine terminals affect truck traffic around ports located near metropolitan areas. For example, trucks queuing at terminal gates can affect traffic flow on nearby streets.

Some port authorities have instituted offpeak (evening and weekend) hours for terminal access. For example, the OffPeak program at the Ports of Long Beach and Los Angeles in California charges a fee on containers moved during peak hours, which provides a financial incentive for trucks to visit the ports during offpeak hours. Roughly half of daily truck-borne container traffic now occurs through the OffPeak gates. Other terminal operators are moving to appointment systems to spread out truck traffic and reduce traffic congestion near their gates.

Many factors influence the transportation modes used for any given freight shipment. However, for freight movements that begin or end in cities, finding modal alternatives that effectively compete with trucks can be difficult.

Some agencies have been able to induce mode shifts in urban areas using public investments and other policy tools. In New York City, the construction of a solid waste recycling facility at the South Brooklyn Marine Terminal has enabled the shipping of recycled materials by barge instead of by truck. The New York City Economic Development Corporation estimates that using barges instead of trucks reduces truck travel by 260,000 vehicle miles (420,000 vehicle kilometers) annually.

"Our waterfront site allows us to both receive and export the majority of materials by barge throughout the New York metropolitan area, removing trucks from city streets and essentially adding floating mobile storage capacity in a city where space is always at a premium," says Sam Silver, the education and outreach coordinator for Sims Municipal Recycling, the operator of the recycling facility.

In hopes of further reducing truck traffic, the New York City Economic Development Corporation is engaged with other partners, including the U.S. Maritime Administration, to bring more maritime cargo operations to this location.

Freight Consolidation

Some urban freight strategies seek to reduce freight traffic by consolidating freight into fewer but fuller

Research funded by the European Commission is investigating how to reduce truck trips related to deliveries of construction materials by using urban consolidation centers. *Photo: © 123RF.com.*

Truck side guards, such as those shown on this delivery vehicle in Cambridge, MA, are vehicle-based safety devices designed to keep pedestrians, bicyclists, and motorcyclists from being swept under and run over by a large truck's rear wheels in a side-impact collision.

vehicle trips. One of these strategies is to establish urban consolidation centers, which are logistics facilities that collect freight from multiple carriers and consolidate them into fewer vehicle trips to an area. By reducing the vehicle miles traveled by freight vehicles in and around the target area, consolidation centers can reduce congestion, noise, and emissions of air pollutants. This strategy can further increase environmental benefits by using low-emission vehicles for the last delivery leg from the consolidation center.

These centers are not common in the United States, but there are numerous consolidation centers operating in Europe, including a dozen located in and around London, England, that serve the construction sector. The European Commission is actively funding research and pilot testing of urban consolidation centers. One of the commission's ongoing projects, titled Sustainable Urban Consolidation Centers for Construction (SUCCESS), is testing different models for consolidation centers for construction materials. Another project, known as CityLab, is identifying opportunities to consolidate freight shipments to large municipal organizations (such as local authorities, hospitals, and universities) in the United Kingdom.

Safety Strategies

Trucks present many safety challenges for operators and other road users. The sizes and shapes of trucks make it difficult, if not impossible, for a truck operator to see all areas of the roadway adjacent to the vehicle. Pedestrians, bicyclists, and motorists caught in these blind spots run a greater risk of being involved in a crash related to truck turns or maneuvers.

Under-riding during collisions presents a safety risk because of the high ground clearance and long wheelbase of trucks. Under-riding occurs when a pedestrian, bicyclist, or other road user becomes caught beneath a truck's wheel during a collision. This type of crash may occur when, for example, a truck makes a right-hand turn while a bicyclist is riding along the truck's right (passenger) side in a bike lane or on a roadway shoulder.

Cities around the world use a variety of strategies to make truck interactions with other road users safer. The following are a few examples.

Vehicle Features

The size of medium- and heavy-duty trucks limits the driver's view around the vehicle significantly more than is true in smaller vehicles. A truck driver must depend on indirect vision, using mirrors and other devices to see many of the areas abutting the vehicle. A 2006 analysis of national crash data found that 20 percent of truck crashes occur in configurations where the visibility limitations of truck drivers might have been an important factor contributing to the crash.

Federal regulations require that trucks with a gross vehicle weight rating greater than 10,000 pounds (4,500 kilograms) have a rearview planar mirror on each side of the cab, but the standard does not require any other mirror type. Some States and municipalities have enacted requirements for additional mirrors on large trucks to increase driver awareness and help prevent fatal crashes with bicyclists and pedestrians, particularly in urban areas. For example, the States of New York, Oregon, and Washington have required additional mirrors on certain types of trucks registered in those States.

Truck side guards also can increase safety. These devices cover the exposed space between the front and rear wheels of a truck or trailer, helping shield pedestrians and cyclists from being swept underneath the truck's wheels. Side guards can be installed on existing trucks or incorporated into designs for new vehicles. Following a national mandate in 1986 for side guards in the United Kingdom, cyclist fatalities in certain types of side-impact collisions with trucks decreased by 61 percent and pedestrian fatalities by 20 percent.

In the United States, the Boston City Council passed the first ordinance requiring truck side guards in 2014. Since then, a growing number of cities have adopted the use of side guards by municipal truck fleets. Cities include San Francisco, CA;

Washington, DC; Fort Lauderdale and Orlando, FL; Chicago, IL; Cambridge and Somerville, MA; New York, NY; Portland, OR; and Seattle, WA.

"In Boston, we looked at the crash data and knew we needed to do something to address the conflict between trucks and vulnerable road users," says Kristopher Carter of the Boston Mayor's Office of New Urban Mechanics. "If I were to provide one piece of advice to our peer cities—don't wait. [Sideguards] have real safety impacts for roadway users who need the most support."

Driver Training

Some cities are encouraging or requiring certain populations of truck drivers who operate in cities to take specialized training on safe operations in urban environments. For example, the San Francisco Municipal Transportation Agency (SFMTA) developed a safety curriculum and video training to reduce the number of bicycle and pedestrian fatalities caused by collisions with large vehicles. SFMTA requires city-employed, city-contracted, and city-permitted drivers of vehicles over 10,000 pounds (4,500 kilograms) to complete the training. The program also encourages private companies to adopt the training and to incorporate safety principles of urban driving into California's curriculum for commercial driver licensing. More than 4,500 drivers completed the SFMTA training between July 2015 and September 2016.

Environmental and Livability Strategies

Metropolitan freight movements can have environmental (emissions) and quality-of-life (noise) impacts on urban neighborhoods. On a national scale, diesel-powered freight vehicles are among the largest contributors to freight-related emissions. These vehicles have a longer operational life than others and can stay in operation for 30 years or more.

Newer diesel-powered freight vehicles and vessels are far cleaner than older diesel models. However, the stricter standards for new vehicles and vessels do not address emissions from the millions of older models still in operation. At the city level, the vehicles used to move freight can concentrate air emissions near ports, distribution centers, and other locations that attract large volumes of freight traffic.

Noise from freight facilities and vehicles is another potential community concern arising in urban areas. Noise results from various sources, including truck engines, refrigeration units for trailers, backing alarms, and loading and unloading activities. Nighttime noise also could be an obstacle to off-hour delivery.

However, transportation agencies and trucking companies can reduce or mitigate the impacts of emissions and noise. Helpful measures by fleet owners include installing idle-reduction equipment on trucks and training drivers to minimize idling while vehicles are stopped. Fleet owners can also deploy alternative-fuel vehicles that produce lower or no tailpipe emissions while having the added benefit of being quieter than traditional diesel models.

In particular, the areas around urban ports face environmental and livability concerns because of the high concentrations of freight vehicles. Many urban ports in the United States are taking steps to reduce their impacts on neighboring communities. For example, the Massachusetts Port Authority (Massport) is addressing livability concerns as part of its planned expansion of container operations at its Conley Terminal in South Boston.

Massport is implementing facility and operational improvements at the terminal, including adding a new access road that will remove as many as 900 truck trips per day from nearby streets. The terminal will have expanded queuing areas for trucks, which will reduce the incidences of freight vehicles idling on city streets near residences. In addition, Massport is installing a sound attenuation wall that will serve as a significant noise and visual buffer for the adjacent residents. Finally, the project includes the creation of a 4.2-acre (1.7-hectare) park, a new amenity for the neighborhood.

"We are proud of the work we are doing to further container operations at the Conley Terminal," says Massport CEO Thomas P. Glynn, "and to alleviate the environmental and noise concerns of

As part of the expansion of its Conley container terminal in South Boston, Massport is building a new access road, shown here crossing a waterway, to remove trucks from local streets. *Photo: Kevin McWeeney, Massport.*

As part of its expansion of the Conley container terminal, Massport is constructing a park and a sound attenuation wall, visible to the right behind a row of trees. *Photo: Kevin McWeeney, Massport.*

residents, while also providing new green space for the community."

Communication, Coordination, and Collaboration

Moving freight in urban areas involves coordination among a wide range of stakeholders in both the public and private sectors. Each of these stakeholders has a unique set of authorities or responsibilities for decision making. In addition, stakeholders often have different goals that might not align precisely.

To increase the chances of success, any strategies to address the challenges of urban freight movements should be implemented in collaboration with local freight stakeholders. Additional opportunities to improve communication, coordination, and collaboration among freight stakeholders in urban areas also are helpful in achieving goals.

State and Regional Freight Plans. Developing State and regional freight plans provides stakeholders an opportunity to bring their concerns and solutions to the table, share priorities, and identify areas of focus. The 2015 Fixing America's Surface Transportation (FAST) Act requires that States seeking to continue using funding from the National Highway Freight Program must develop a FAST Act-compliant State freight plan by December 4, 2017; guidance is available at http://ops.fhwa.dot.gov/freight.

Freight Advisory Committees. Freight advisory committees offer a structured forum for relevant stakeholders to provide their insights and expertise to freight-related issues, priorities, projects, and funding needs in a State or region. The FAST Act encourages State departments of transportation to establish a State freight advisory committee consisting of a representative cross section of public and private freight stakeholders. Many metropolitan planning organizations also have freight advisory bodies of some kind.

Designation of Critical Urban Freight Corridors. The FAST Act provides an opportunity for States and metropolitan planning organizations to designate a limited number of road miles as critical urban freight corridors. These corridors provide critical connectivity to the National Highway Freight Network. The process of designating the corridors is another opportunity for freight stakeholders to communicate, coordinate, and collaborate on decisions that affect the mobility of freight in their cities or regions. No deadline exists for designating critical urban freight corridors—FHWA considers the designations on a rolling basis.

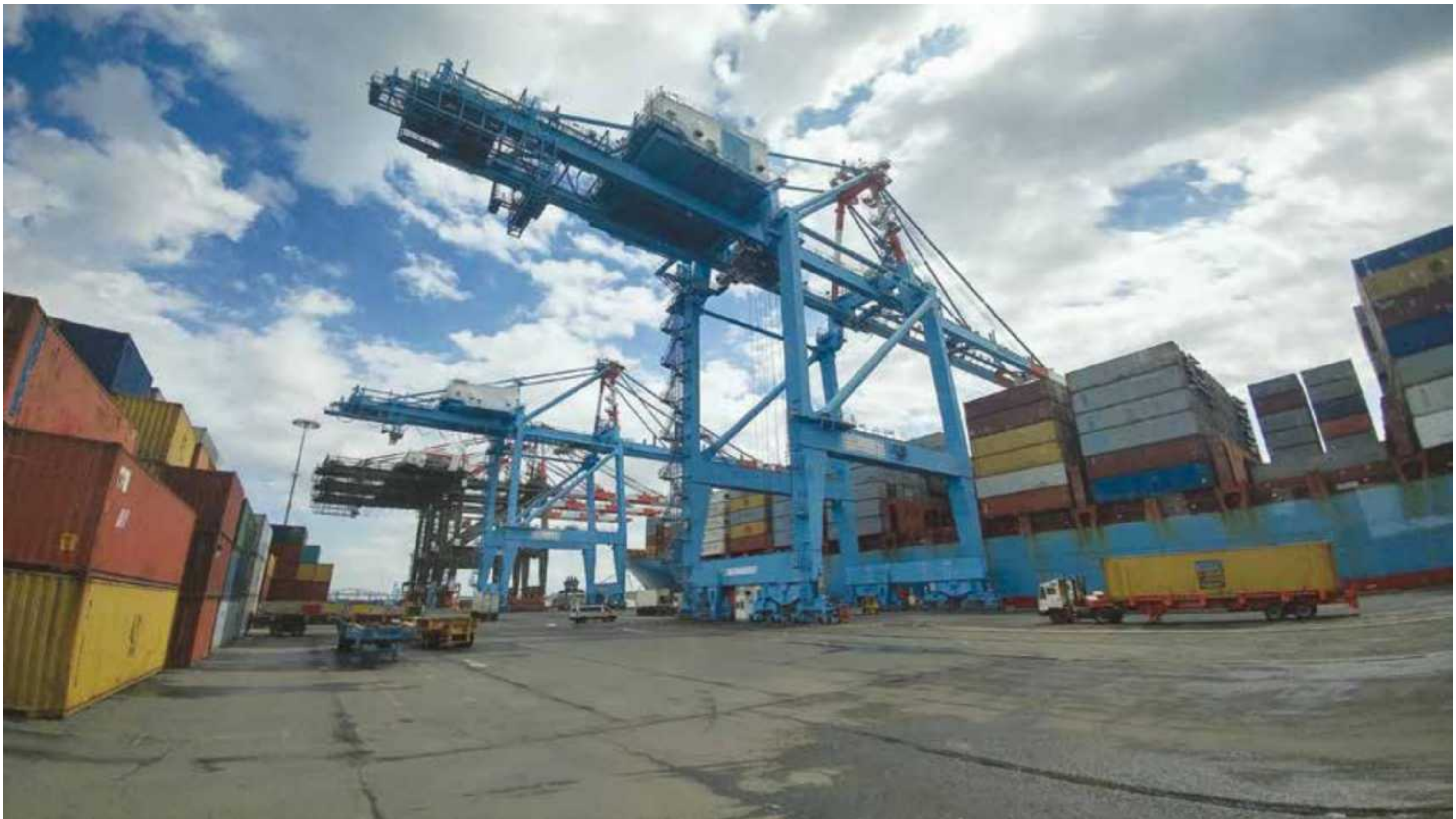
Public-Private Partnerships and Joint Initiatives. In some areas of the country, private companies involved in transportation and logistics have joined together to advance their mutual interests, including providing information for public decision making that affects freight transportation. Public agencies can tap the collective expertise of such organizations to inform investment and funding choices for transportation infrastructure and other freight-related policy decisions.

In Indiana, the Conexus Indiana Logistics Council (CILC) is a statewide partnership of logistics executives and stakeholders working together to implement strategic initiatives around infrastructure, innovation, public policy, and workforce development needs. CILC serves as a bridge between the private sector and government in terms of freight planning and funding. The Indiana Department of Transportation works closely with the council to ensure that the State's projects meet freight needs. For example, the department is working with CILC to find smaller projects in cities and towns that can be completed quickly but provide a significant improvement in freight mobility.

Downtown Delivery Symposiums. With support from FHWA and the Institute of Transportation Engineers, Philadelphia, PA, and Baltimore, MD, have held events to bring freight stakeholders together to discuss freight issues in their commercial districts. These downtown delivery symposiums offered freight stakeholders from both public and private sectors an unprecedented opportunity to air concerns and discuss potential solutions. FHWA is actively seeking additional cities that would like technical assistance to host a downtown delivery symposium of their own.

Preparing for the Future

USDOT anticipates that national and international trends will push freight volumes higher, with the majority of future population growth occurring in metropolitan areas. These trends make it increasingly important for transportation



Transportation agencies and communities can collaborate to find solutions for urban freight movement, including managing the routing, timing, and flow of trucks serving urban ports like this one.

decisionmakers to focus on freight mobility in metropolitan areas.

To meet the freight challenges ahead, transportation agencies at all levels will need to consider the full gamut of strategies. Some of these include land-use planning, zoning, pricing of roadways and parking, and the use of intelligent transportation systems. In addition, as connected and automated vehicle technologies mature, there will likely be opportunities to harness them to improve freight mobility in metropolitan areas. Nevertheless, the strategies outlined here are ones that transportation agencies can implement now.

FHWA is developing two primers that will detail strategies to help State and local agencies tackle the challenges of urban freight movements. FHWA will continue to work with its State and local partners, as well as researchers and agencies from other countries, to identify and promote effective strategies for managing urban freight.

FHWA is also advancing urban freight research through partnerships with the European Commission and ongoing collaboration with the Transportation Research Board's (TRB) Standing Committee on Urban Freight Transportation. "Our ongoing partnership with FHWA provides our far-reaching research community a linkage to practitioners," says Bill Eisele, chair of the TRB Urban Freight Transportation Committee and senior research engineer at the Texas A&M Transportation Institute. "These fruitful, two-way dialogues are the first step to successfully implementing urban freight strategies and innovations."

Cities around the world face the common challenges of feeding, clothing, and supplying people and businesses. In response to these challenges, FHWA is developing resources to improve truck parking, performance measures, off-hours delivery, and freight data.

"Our urban areas must be prepared to accommodate the population growth anticipated for the coming decades," says Caitlin Hughes Rayman, director of FHWA's Office of Freight Management and Operations. "To thrive, cities require a resilient, efficient, affordable, and safe transportation system. In light of these needs, it is imperative that FHWA and its partners continue to share innovations in goods movement to preserve and enhance the quality of life for citizens here and across the globe."

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For more information, visit https://ops.fhwa.dot.gov/freight/technology/urban_goods/index.htm or contact Tamiko Burnell at 202-366-1200 or tamiko.burnell@dot.gov.

Getting Around Town

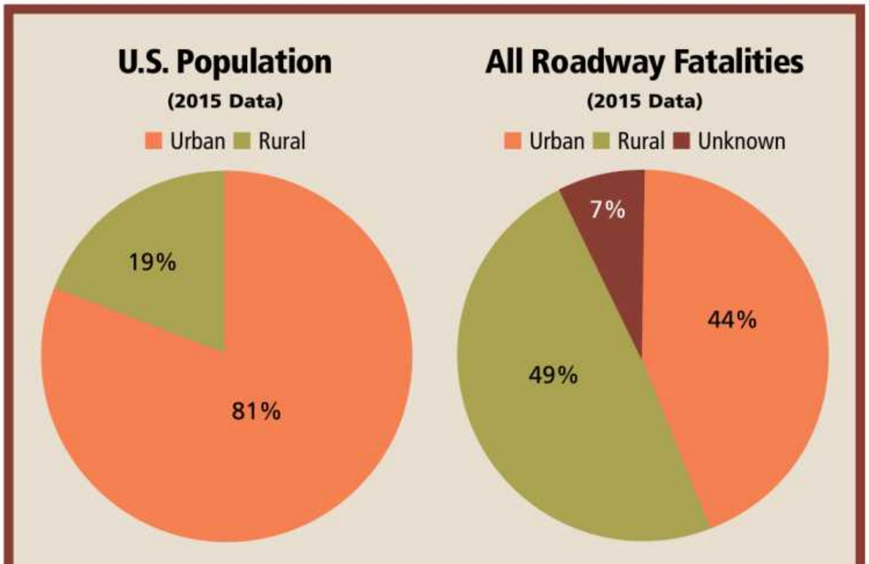
by Daniel Goodman

A new guide from FHWA can help small communities and rural areas build multimodal transportation networks that benefit users of all ages and abilities.

(Above) These bicyclists are traveling on the Constitution Trail, a shared use path that runs through Bloomington and Normal, IL. *Photo: Diane Banta, National Park Service Rivers, Trails, and Conservation Assistance Program.*

In rural communities and small towns across the United States, walking and bicycling for transportation are part of everyday life. People walk to grocery and convenience stores, children bike to school and to their friends' houses, and others park their cars and then walk to the businesses on their town's "Main Street." Some people walk and bicycle for transportation by choice, and others do so because it is their only option to get to their jobs and other necessities. According to the 2009 National Household Travel Survey, nearly 10 million households, or almost 9 percent of the total in the United States, do not have access to a motor vehicle.

People in rural areas face unique challenges in getting around, especially those who do not drive.



Around 19 percent of the U.S. population lives in rural areas, but nearly half of all roadway fatalities occur in rural areas. *Source: FHWA.*

Destinations are farther apart, and dedicated infrastructure (for example, sidewalks and bike lanes) is often not available, which can make walking and bicycling difficult and uncomfortable. In these cases, pedestrians and bicyclists are sharing the roadway with motor vehicles and there may not be a crosswalk or a traffic signal to help them cross the road for miles.

In part because of these challenges, rural areas are overrepresented when it comes to traffic fatalities and serious injuries. Although only 19 percent of the U.S. population lives in rural areas, 49 percent of all traffic fatalities and serious injuries occur in those areas.

And notably, although overall roadway fatalities declined 25 percent from 2005 to 2014, pedestrian fatalities as a percentage of those total fatalities rose from 11 percent to 15 percent and bicyclist fatalities rose from 1.8 percent to 2.2 percent. With additional increases in pedestrian and bicyclist fatalities in 2015 and 2016, nearly one out of five roadway fatalities in the United States involve a person walking or biking.

Everyone deserves to be able to get to and from work, school, and other necessities safely. One way to improve safety, while meeting the transportation and mobility needs of people in rural and small town areas, is to build connected networks of multimodal infrastructure that enable all travelers to reach where they need to go safely and comfortably. The Federal Highway Administration offers a guide, *Small Town and Rural Multimodal Networks* (FHWA-HEP-17-024), for practitioners developing and promoting multimodal networks in small and rural communities.

Building Connected Networks

Connected multimodal networks in rural areas make walking and bicycling a viable transportation choice. They improve safety for everyone by organizing the roadway environment and enhancing visibility and predictability. The network may have varying facilities that appeal to a range of ages and abilities, such as shared use paths, sidewalks, and bike lanes.

These facilities also provide equitable transportation for people of all ages and income levels. They promote independence for young people, and they can enable older people to age in place. They also enhance access to jobs, an especially important consideration given that unemployment rates in rural areas are consistently higher than those in urban areas or nationwide.

Multimodal networks in rural areas share some common features and attributes with networks in urban and suburban areas. For example, a small town's main street can function like an urban space even if it is only a few blocks long. The space requires sidewalks, onstreet parking, and accommodations for deliveries to local businesses. Also important is the high demand for pedestrian crossing opportunities and a clear safety rationale to actively manage the speed of motor vehicle traffic.

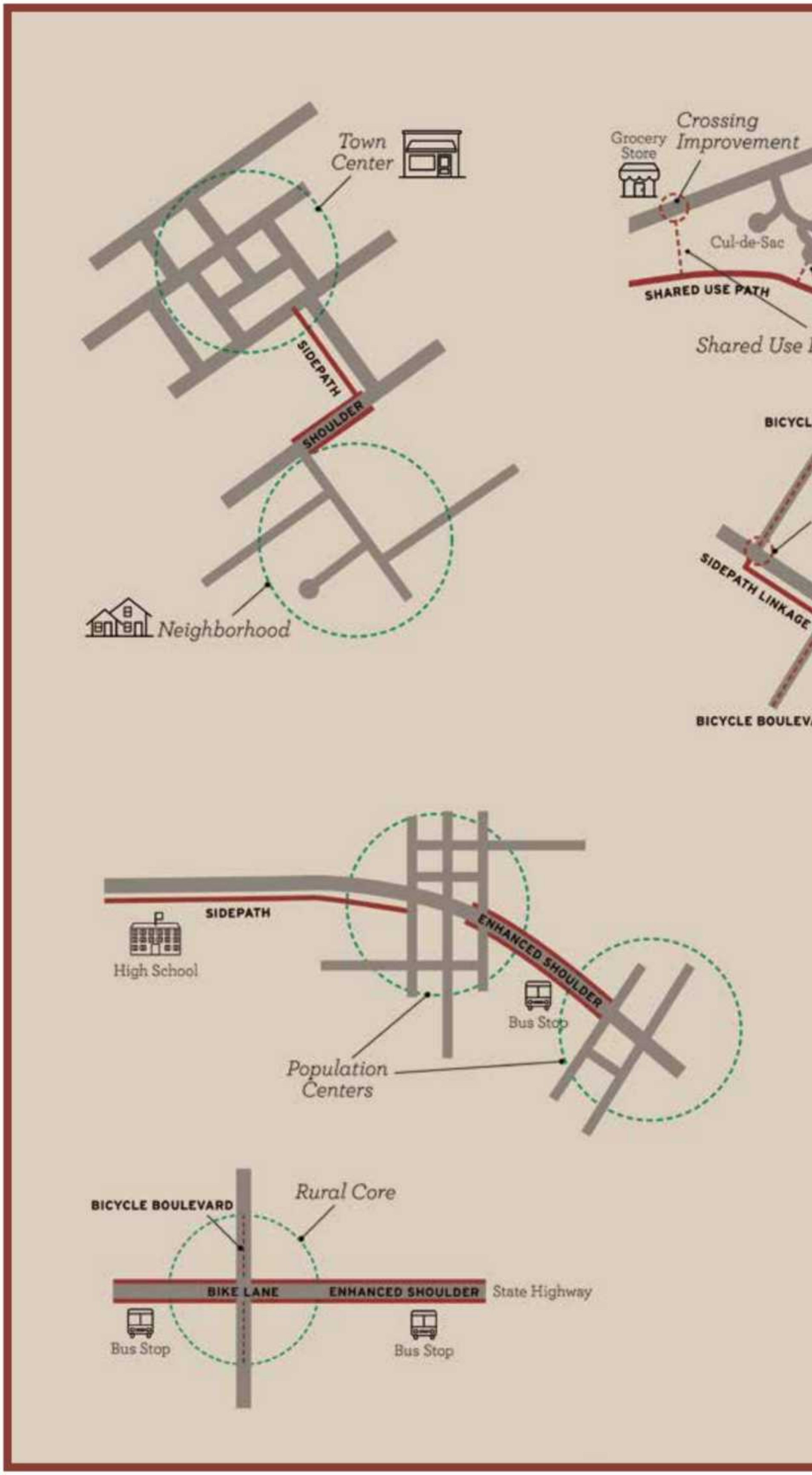
A "one-stoplight town" may have only a few business establishments clustered together, but that signalized intersection is functioning like a suburban or urban place, serving many purposes and travelers throughout the day and night. In many small towns and rural communities, active transportation—any self-propelled, human-powered mode of transportation—is even more common than it is in urban areas, but the roadway designs often favor high-speed motorized traffic.

Rural multimodal networks also have many unique features to overcome. For example, significant stretches between destinations often make it infeasible to build long expanses of sidewalk. As a result, people do more of their walking and biking on roadway shoulders in rural areas.

If a comfortable residential street feeds pedestrians out onto a State highway with cars going 60 miles (97 kilometers) per hour without a sidewalk or shoulder, that road is not a safe or viable route to get those walkers where they need to go. Likewise, if a high school sits on the outskirts of town on a road with fast traffic, with no dedicated multimodal facilities, and with no safe way to cross to the other side of the street, that highway is not going to meet the needs of the children and adults trying to get to and from school.

On the other hand, some residential streets are often comfortable for biking because of the low volume of cars. In this case, even if available space exists for a bike lane, no clear rationale exists for adding one. Context and function are important factors in meeting the needs of all travelers.

In most cases, people are unlikely to forego travel to key destinations because of these obstacles. They will travel out of necessity, but be less comfortable and potentially less safe. They might even create issues for drivers (for example, by crossing



A connected network in a rural and small town setting is not simply a single trail, sidewalk, or bike lane. A connected network has many interconnected facilities that enhance access to key destinations, such as town centers, schools, bus stops, and stores, and support walking and bicycling throughout the community. *Source: FHWA.*

Multimodal Networks in Action

Multimodal Network Principle	Description of Network Principle	Case Study	Summary
Cohesion	How connected and linked together is the network?	Pickens and Easley, SC  *Photo: Alta Planning + Design.*	A shared use path serves as a transportation and recreation corridor for residents and visitors, and enhances connectivity between the two communities. The city of Pickens developed bike lanes to connect to downtown Pickens. The city of Easley is extending the trail into its downtown and has provided bike lanes for alternate connections to Baptist Easley Hospital and cultural amenities.
Directness	Does the network provide direct and convenient access to destinations?	Lyndonville, VT  *Photo: Vermont Agency of Transportation.*	The buffered bike lanes on Main Street in Lyndonville are part of a network of on-street bike lanes and shared streets that connect the downtown businesses with residential streets and Lyndon State College.
Accessibility	Does the network provide access to destinations for persons of all abilities?	Miles City, MT  *Photo: Alta Planning + Design.*	The sidewalk installed as part of this project in Miles City, MT, connects low-speed, low-volume neighborhood streets to a network of existing sidewalks in the area around Garfield Elementary School. It provides an accessible pedestrian route and a critical network link between homes, school, and a park.

Alternatives	Does the network enable a range of route choices?	Manzanita, OR  *Photo: Alta Planning + Design.*	Manzanita's local streets connect residences with the ocean, parks, and the downtown. The ability to use these shared local streets enables pedestrians and bicyclists to access all parts of the community.
Safety and Security	Does the network provide routes that minimize risk of injury, danger, and crime?	Ennis, MT  *Photo: Western Transportation Institute.*	The facilities in Ennis connect neighborhoods to schools and businesses throughout the community. In this small town, residential streets that connect neighborhoods to schools can be shared by people walking, biking, and driving. Lighting and a clear view of the path ahead are important safety and security components.
Comfort	Does the network appeal to a broad range of age and ability levels and is consideration given to user amenities?	Connellsville, PA  *Photo: Saara Snow, Adventure Cycling Association.*	The separated bike lane, which appeals to a broader range of existing and potential bicyclists because of the separation from motor vehicles, is the connection of the Great Allegheny Passage (GAP) through Connellsville. Connellsville's *Bicycle Master Plan* builds off this key element in establishing a broader network that will connect people on bikes from the trail to businesses across the city and Connellsville residents to the GAP.

the road at unmarked locations, or taking the full lane on a road because there is no other safe travel option). For these reasons, a critical need for multimodal network connectivity exists in these situations.

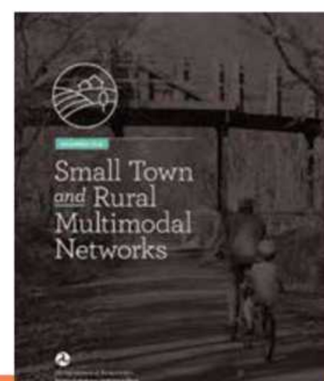
FHWA's Guide

In 2017, FHWA published a resource to help rural and small town communities plan, design, and implement safe and comfortable multimodal networks. The *Small Town and Rural Multimodal Networks* guide focuses on the concept of connected networks that meet the needs of everyone in a rural and small town context.

The guide helps communities visualize multimodal networks appropriate to the land use setting. It provides a toolbox of facility types that, when thoughtfully pieced together, will make up a connected network for pedestrians and bicyclists. The facilities, which are tailored to rural land use and roadway characteristics, build on existing national design guidelines, while also recognizing geographic and fiscal constraints in rural areas and the need for design flexibility.

The guide will help agencies identify and implement incremental improvements, often in retrofit situations, which will enhance safety, access, and mobility.

"The *Small Town and Rural Multimodal Networks* guide is serving as a primer for the Commonwealth's towns and villages looking to maximize their return on investment," says Peter Sutton, bicycle and pedestrian program coordinator at the Massachusetts Department of Transportation.



FHWA's *Small Town and Rural Multimodal Networks* report is a resource and idea book intended to help small towns and rural communities support safe, accessible, comfortable, and active travel for people of all ages and abilities.

FHWA's report provides design information for a variety of facility types applicable to small town and rural settings, such as the paved shoulder example shown here. It builds on existing national design guidance, encourages innovation, and highlights case studies from small towns and rural communities throughout the United States. *Source: FHWA.*

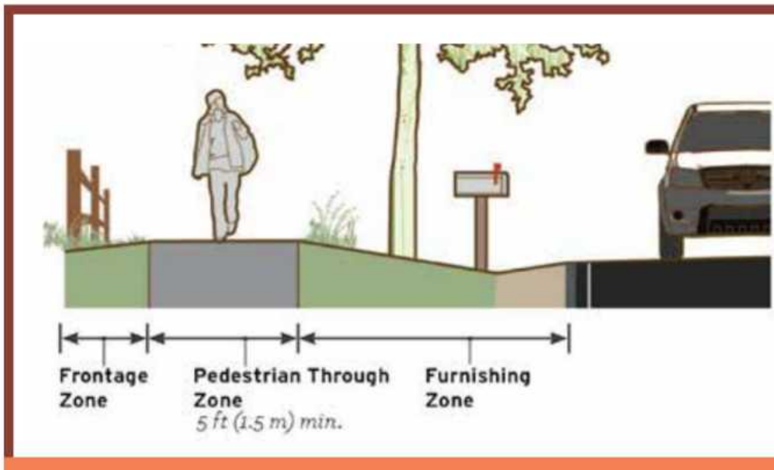
Types of Tools

The guide presents the toolbox of pedestrian and bicycle facility types in three categories: mixed traffic, visually separated, and physically separated.

The mixed traffic category includes "yield roadways," which serve all users in a slow speed travel area. This design is common in rural neighborhoods today. The category includes bike boulevards, which prioritize the operation of bicycles within roadways that are shared with motor vehicles, and it includes an innovative facility called advisory shoulders. The advisory shoulder creates a useable shoulder for bicyclists on a roadway that is otherwise too narrow to accommodate one by providing a delineated but nonexclusive space. Because it is a new treatment, the advisory shoulder requires a request to experiment from FHWA, which is a formal process for evaluating safety and operational conditions before and after installation.

Visually separated facilities include paved shoulders and bike lanes. As with all facility types, the guide provides information on speed, volume, and land use considerations tailored to the rural context. It also offers details on geometric designs covering topics such as rumble strip placement and the treatment of shoulders at intersections.

The physically separated category includes shared use paths, sidepaths (bidirectional shared use paths located immediately adjacent and



This image from the *Small Town and Rural Multimodal Networks* guide shows how sidewalks should be physically separated from the roadway by an unpaved buffer separation, barrier, or curb edge. *Source: FHWA.*

parallel to a roadway), sidewalks, and separated bike lanes. For shared use paths, the guide includes detailed information about designing safe roadway crossings. For sidepaths, the publication has information on designing for the transition from a sidepath to a paved shoulder. The guide also provides information on the frontage zone (adjacent to the property line, to enable people to enter and exit buildings), pedestrian through zone (for pedestrian activity and wide enough for two people to walk side by side), and furnishing zone (closest to the street, to provide space for mailboxes, signs, light poles, and other utilities) of sidewalks, and detailed guidance on signs and markings throughout.

Some information provided in the guide supplements previously available resources from FHWA. The guide demonstrates how rural areas can implement separated bike lanes, building on FHWA's 2015 *Separated Bike Lane Planning and Design Guide* (FHWA-HEP-15-025). It also highlights the appropriate application of design flexibility and in doing so builds on FHWA's *Achieving Multimodal Networks* (FHWA-HEP-16-055) guide.

In addition to detailed planning and design information about multimodal facility types, the guide highlights opportunities to enhance safety (for example, by improving multimodal school connections and implementing speed management techniques). Guide users also receive extensive information about addressing network connectivity, and the publication demonstrates how to achieve these improvements as a part of the transportation planning and delivery process.

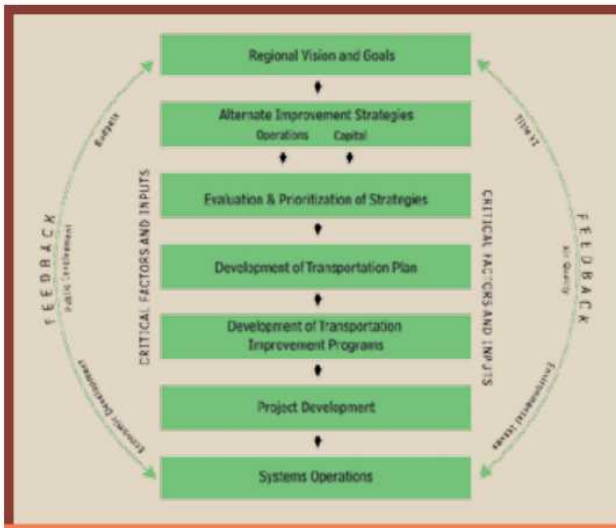
A Changing Perspective

People have always walked and biked for transportation in small towns and rural areas. The challenge for transportation practitioners today is to identify and implement strategic improvements to enhance safety for everyone, including those who are traveling on foot and by bike.

Transportation professionals across the country are adopting a multimodal network perspective that does not treat individual projects as standalone activities, but rather as pieces of a broader multimodal network. They recognize that such a network is critical for people to access jobs, schools, and other destinations, and to get where they need to go safely and comfortably regardless of which transportation mode they use.

Accommodating all travelers promotes transportation system efficiency, economic development, and even tourism in some locations. A transportation system that works for everyone also leverages other investments, for example in bridges and transit, and it serves as a market-driven response to transportation priorities.

"Our goal with the *Small Town and Rural Multimodal Networks* guide," says Gloria Shepherd, associate administrator for planning, environment, and realty with FHWA, "is to meet State and local demand and address the transportation needs of all people."



Multimodal networks are achieved through the State and locally led transportation planning process, which includes a broad range of activities and products. *Source: FHWA.*

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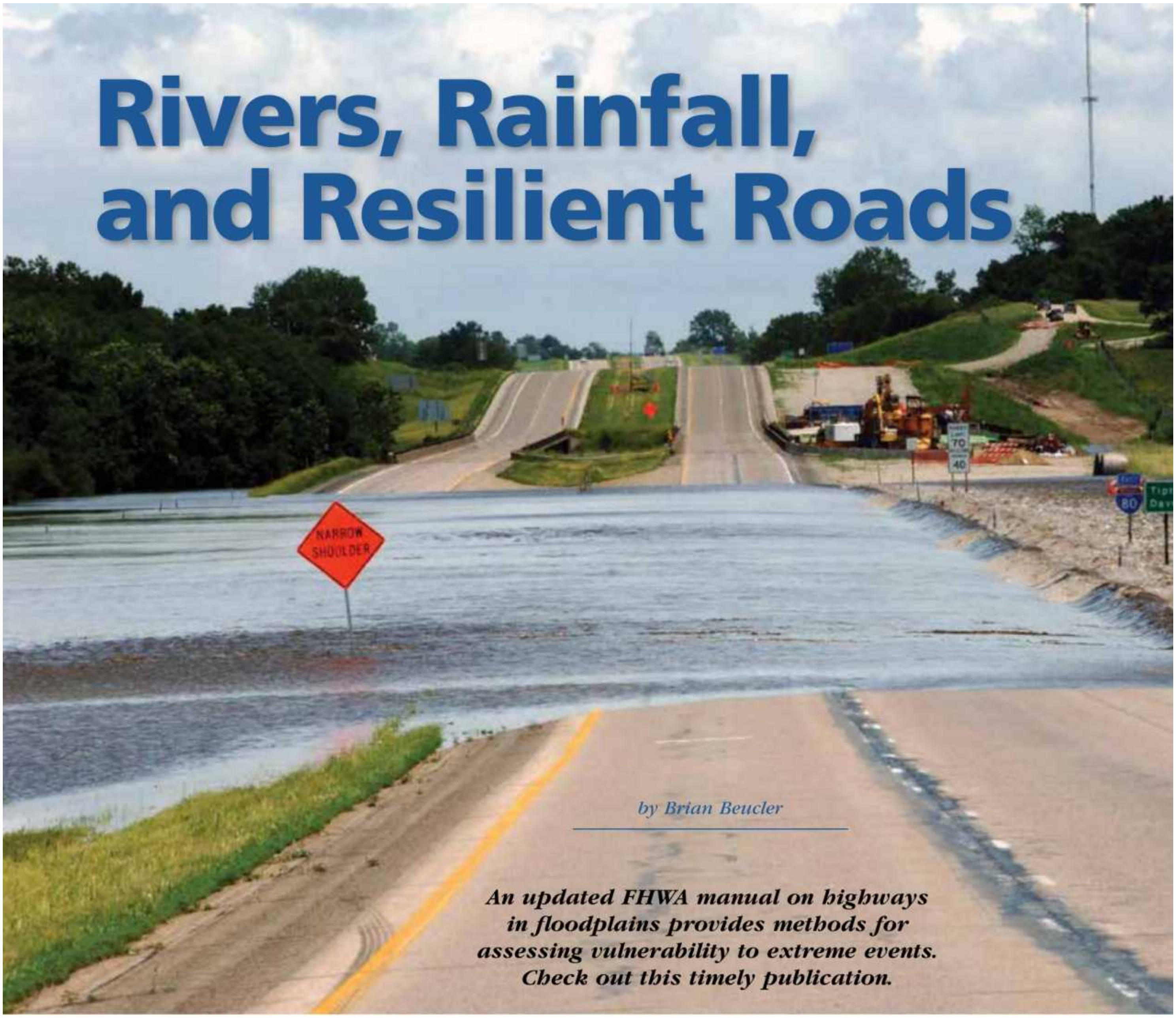
Networks are interconnected pedestrian and bicycle transportation facilities that enable people of all ages and abilities to get to where they want to go safely and conveniently. *Photo: Tom Robertson, Adventure Cycling Association.*

Rivers, Rainfall, and Resilient Roads



by Brian Beucler

An updated FHWA manual on highways in floodplains provides methods for assessing vulnerability to extreme events. Check out this timely publication.

Almost every day, it seems, news outlets show scenes of homes and communities flooded somewhere in the United States. Given the formidable power of rushing water, the floods could have substantial impacts on the Nation's communities, highways, and bridges.

What are the impacts of extreme floods, are dangerous floods more frequent, and what can State departments of transportation do to lessen future damage to their road networks? To find out, read on.

The phrase used by scientists and transportation planners—the "riverine environment"—refers to waterways, rivers, streams, lakes, wetlands, and other natural resources that convey water. The riverine environment also includes floodplains, which are land areas that are susceptible to inundation resulting from the overflow of adjacent rivers and streams. Many roads, bridges, and other components of transportation systems are located adjacent to or near the riverine environment.

Floodplains are subject to extreme floods, such as the 1,000-year flood of June 2016 in West Virginia, which killed 23 people, and the June 2008 flooding in the Iowa and Cedar River basins in Iowa, which necessitated $1.3 billion in Federal disaster assistance and an additional $583 million obligated for improvements to infrastructure. Extreme floods are driving the need to develop more resilient approaches to the planning, design, and operation of transportation systems located within floodplains.

To address this need, State DOTs are scrutinizing their budgets to ensure that investments in highway infrastructure consider the risks to roads, bridges, and culverts in the face of extreme floods. With risks increasing because of development in floodplains, DOTs are looking to improve the

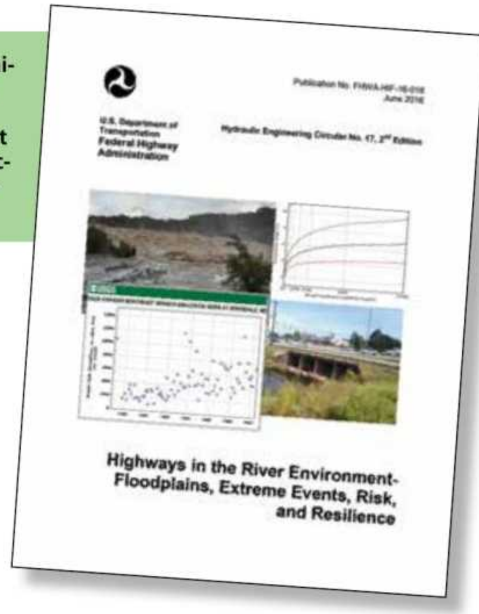
In June 2008, the Cedar River at Cedar Rapids in Iowa had catastrophic flooding that exceeded the 500-year flood by 1.4 times. Downstream, I–80 was closed for 4 days and required a 120-mile (193-kilometer) detour.
Photo: Dave Claman, Iowa DOT.

resilience of transportation infrastructure to dangerous floods.

Consequently, transportation agencies need updated and expanded guidance on methods of assessing the risks, techniques for estimating extreme floods (including changing precipitation patterns), and strategies for reducing the vulnerability of transportation assets to extreme events.

To fulfill these needs for guidance and strategies, the Federal Highway Administration published the second edition of Hydraulic Engineering Circular No. 17 (HEC-17) *Highways in the River Environment—Floodplains, Extreme Events, Risk, and Resilience* (FHWA-HIF-16-018) in June 2016. This updated publication contains more than 150 pages and numerous illustrations.

HEC-17 is one in a series of technical reference manuals published by FHWA. The updated second edition addresses risk assessment methods and strategies for reducing the vulnerability of transportation assets to extreme events.



Why a New HEC-17 Manual?

The manual was in need of an update. For one thing, the first edition of HEC-17 was published in 1981—more than 35 years ago.

That initial edition focused on the risk analysis of encroachments, such as highway embankments, in the floodplain. In particular, the publication described a decision-making process referred to as the "least total expected cost" method, which could be applied to a specific asset with its own unique conditions.

The alternative is analyzing risk in terms of a specified design event, such as a 100-year storm (one that has a 1 percent probability of occurring in any given year). Although the first edition of HEC-17 includes important risk concepts, the second edition significantly expands on the subject of risk analysis, while also focusing on extreme events, resilience, climate science, and designing in the face of uncertainty.

In the manual's introduction, FHWA states that it intends HEC-17 to represent the "best available and actionable engineering and scientific data and approaches" that can be applied to the design of riverine highway infrastructure, so that it will be resilient to extreme events in the future. Data and methods that do not meet FHWA's definition of "best available" or "actionable" were purposely excluded from the manual. The approaches outlined in the manual are grounded in sound science and can be clearly implemented without great complexity or ambiguity.

"As climate science and floodplain regulations continue to evolve, FHWA will be updating its technical publications, including HEC-17, to keep pace," says Michael Culp, team leader of the Sustainable Transportation and Resilience Team in FHWA's Office of Planning, Environment, and Realty.

HEC-17 also provides a consistent, nationwide approach to incorporating the potential effects of extreme events and changes in climate, with respect to the hydrologic design of roads, bridges, and culverts. Rather than completely abandon traditional hydrologic design methods, HEC-17 recommends that information from climate models incrementally augment or inform the traditional design, based on the criticality and remaining service life of the asset being considered.

For example, the longer a culvert remains in service, the likelihood increases that it will see a damaging flood. Also, the more expensive the culvert is, and the stronger the increase in precipitation projected by climate models, the more significance the design needs to place on outputs from those models. The manual includes tables and specific numerical recommendations to help the designer determine when, and to what extent, those outputs should be incorporated into designs.

HEC-17 limits its focus to riverine hydrology, floodplains, extreme events, risk, and resilience. A related publication, HEC-25, *Highways in the Coastal Environment: Assessing*

Extreme Events (FHWA-NHI-14-006), addresses the vulnerability assessment of highways exposed to sea level rise and coastal extreme storm events. State DOTs and the American Association of State Highway and Transportation Officials frequently cite and use the concepts contained in HEC manuals to inform their hydraulic manuals and design procedures.

Contents of HEC-17

The manual begins with an introductory chapter on the publication's scope, purpose, and target audience, plus a list of related FHWA guidance materials and Web sites. The next chapter describes the evolution of Federal floodplain regulations and executive orders. The third chapter defines terms and reviews hydrologic methods to compute floods from rainfall/runoff models and statistical methods using streamgages. This chapter also discusses uncertainties associated with traditional hydrologic methods, irrespective of climate impacts.

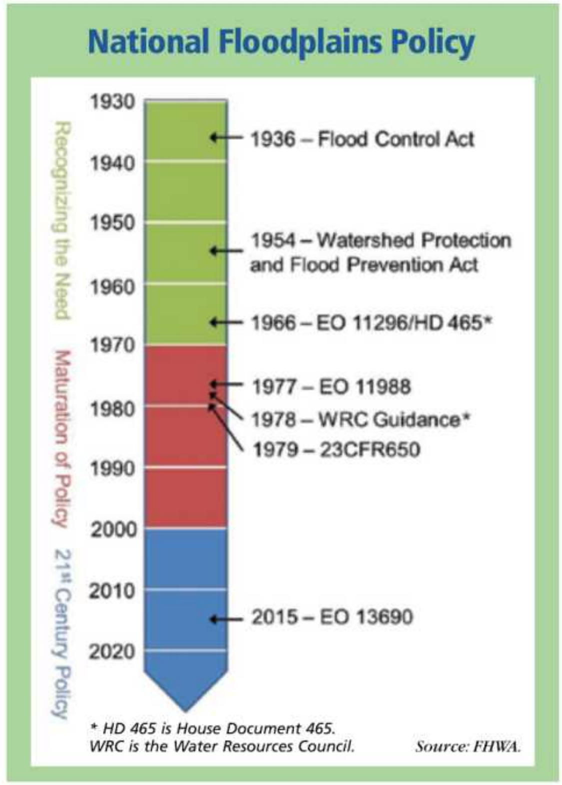
The fourth chapter defines "nonstationarity" (meaning the past is not necessarily a predictor of the future) and lists sources of nonstationarity, including projected future changes in temperatures and precipitation patterns. Also outlined are statistical techniques to adjust datasets for nonstationary effects.

Chapter 5 presents a brief overview of climate science, climate models, and the tools available to extract temperature and precipitation data relevant to the hydrologic design of highway drainage infrastructure. Chapter 6 defines the concepts of risk and resilience and the consequences of failure to modify the design process. Also listed are potential adaptation strategies to increase resilience and reduce vulnerability to extreme events.

Chapter 7 presents a five-level hydrologic design/analysis framework that incrementally increases the consideration of the effects of climate change based on remaining service life, asset criticality, and strength of projected trends (increases) in precipitation amounts. This chapter is the heart of the manual, providing the reader with a practical method to incorporate extreme events and nonstationarity into the hydrologic design of highway assets.

The final chapter outlines several case studies conducted by State DOTs and Federal agencies illustrating the various levels of analyses presented in the previous chapter.

Climate science is a complex and rapidly changing field. Computer models are becoming more sophisticated, and more measurements are being taken of the Earth's reaction to increasing temperatures and changing precipitation patterns. Most aspects of climate science and nonstationarity and even some of the risk and resilience concepts might be new to some DOT designers, so digesting the chapters that precede the five-level analysis framework is critical.



Evolving Federal Floodplain Policy

FHWA developed the manual in 2016 partly as a response to the requirements set forth in sections of Moving Ahead for Progress in the 21st Century (MAP-21) related to floodplain development; Federal Emergency Management Agency (FEMA) regulations governing the National Flood Insurance Program; FHWA orders, such as Order 5520 "Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events"; and 23 CFR 650 Subpart A, the section in the Code of Federal Regulations that deals with the "Location and Hydraulic Design of Encroachments on Flood Plains." For reference, these are all contained in one of the manual's appendices.

The second chapter of the manual helps the reader navigate the history of floodplain regulation. It answers the question, "How did we get here?" It is important to know the lines of authority that FHWA has in floodplain regulation and the mechanisms it can use to reduce the impacts of highway encroachments on floodplains.

Joe Krolak, principal hydraulic engineer in FHWA's Office of Bridges and Structures, says, "In 2012, MAP-21 added 'extreme events' as a new category of considerations, such as scour countermeasures or seismic retrofits, that transportation folks could consider during project delivery. HEC-17 provides FHWA's understanding of how to properly account for extreme events in the riverine environment."

Traditional Hydrologic Design

The manual's third chapter defines key terms and describes traditional methods that engineers use to estimate flood discharges. Hydrologists and hydraulic engineers employ many terms to describe rainfall, runoff, flow in rivers, and flow large enough to be considered a design event or an extreme flood event. In addition, rainfall is more precisely defined as precipitation, which can be in the form of rain, hail, sleet, or snow. Rainfall over a watershed can vary temporally and spatially, especially in larger watersheds.

In addition to considering the size of an event, a second component of hydrologic design is the watershed's reaction to precipitation. How much becomes runoff? How much

Shown is flooding on the Pedernales River in Texas in August 2007. Dangerous flooding like this puts bridges and culverts at risk.

is intercepted by leaves and other vegetation? How much infiltrates directly into the ground based on soil types in the watershed or impervious coverings such as pavements and buildings? How wet and saturated (from recent rainstorms) is the watershed before the precipitation falls? Has the watershed been burned by a wildfire? All these interactions contribute to the accumulation of runoff that eventually produces a peak flow at a specific point in a river, perhaps at a bridge or a culvert.

Floods occur when accumulated flows exceed a river's carrying capacity and land that is normally dry becomes inundated. When scientists describe a flood as a 100-year flood, they are describing the return period of the flood—the *average* length of time between occurrences in which the magnitude of that flood is equaled or exceeded. The time between two 100-year floods can be shorter or longer than 100 years.

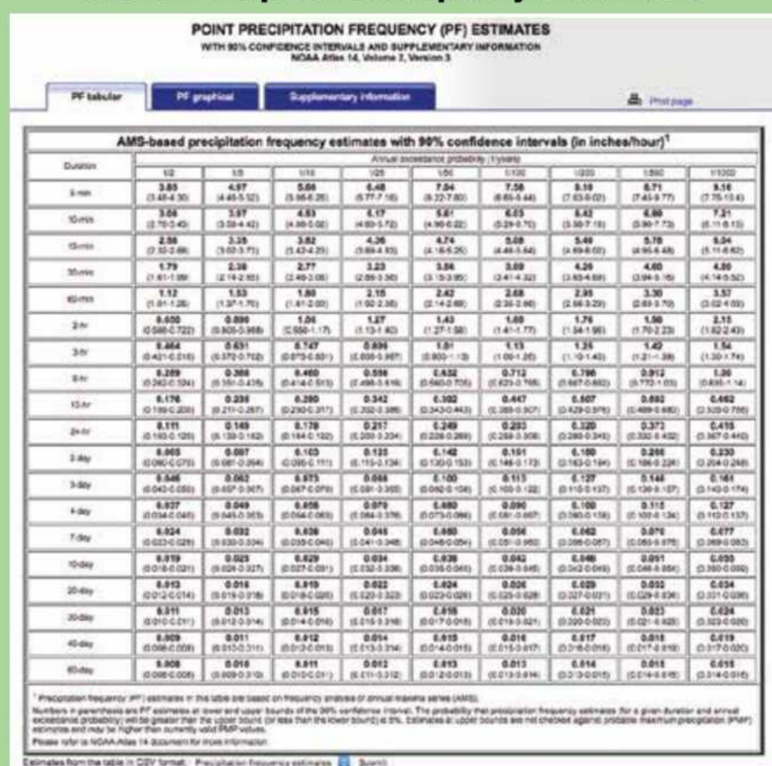
A more useful way of characterizing a 100-year flood is to define the annual exceedance probability (AEP) of the flood. The AEP is the probability that the magnitude of a flood will be equaled or exceeded in any given year. The 100-year flood has a 1-percent chance of being met or exceeded in any given year.

Hydraulic designers may specify a given AEP as the design flood for the infrastructure being designed, depending on the infrastructure's criticality and the risks associated with physical damages and other losses such as traffic interruption. Extreme flood events are not normally used as design floods because designing for them might not be economically justifiable.

The manual's third chapter also classifies two main methods to calculate flood discharges: rainfall/runoff and statistical. Rainfall/runoff models use precipitation in the form of rain as the primary input. Rainfall data are obtained from local or national weather service sources such as the National Oceanographic and Atmospheric Administration's (NOAA's) Precipitation Frequency Data Server.

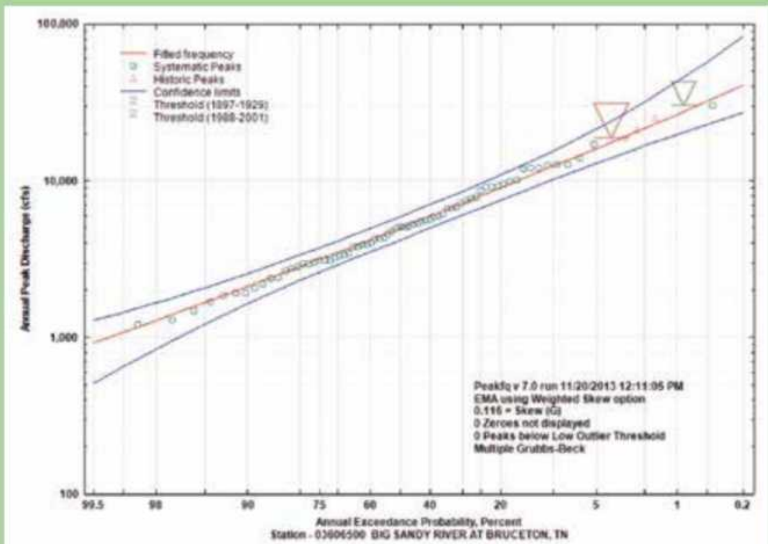
The other method for calculating flood discharges is statistical models, such as regression equations and the Log-Pearson Type III method, which are based on statistical analysis of records taken directly from streamgages. Statistical methods are considered superior

NOAA's Precipitation Frequency Data Server



This screenshot shows precipitation intensities for different durations and annual exceedance probabilities. Ninety-percent confidence intervals are shown in parentheses. *Source: NOAA.*

Flood Frequency Curve



The figure shows an example of a flood frequency curve with confidence limits. The red line curve represents the best fit of a single line to the datapoints showing annual peak flow (the highest daily flow of any year) recorded at a streamgage through its operational history. The measure of uncertainty associated with this line is called the "confidence interval." This interval is defined by an "upper confidence limit" and a "lower confidence limit" represented by the curved blue lines. As annual peak datapoints become more scarce, toward the extremely low (dry) or extremely high (wet) values, the confidence interval becomes wider (more uncertain). HEC-17 encourages designers to consider the full range of values within the blue confidence limits rather than just the computed value (red line). *Source: FHWA.*

important assets or assets that are to remain in service for a long time.

Nonstationarity: The Past Offers No Guarantees

Traditional hydrologic design operates on the assumption of a climate that exhibits stationarity, which holds that data collected from the past is representative of the future. By contrast, nonstationarity means that past patterns or trends may not be valid in the future. As discussed in the fourth chapter of the manual, nonstationarity essentially introduces uncertainty into the use of historical observations for estimating future flooding.

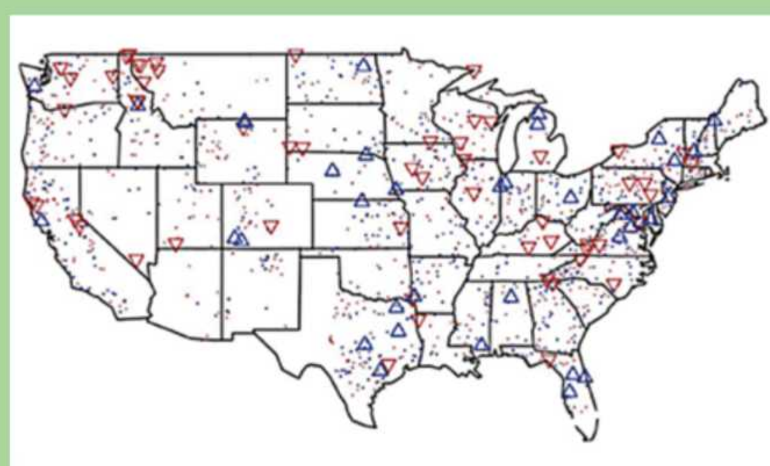
Causes of nonstationarity include changes in watershed land cover from pests, the migration of plant species, wildfires, and urban development (increased impervious surfaces); changes in precipitation patterns; introduction or removal of water storage ponds or dams within a watershed; and stream diversions for municipal (drinking water) or agricultural (irrigation) purposes. Nonstationarity caused by changes in precipitation patterns often can be minor compared to some of these other causes.

Moreover, nonstationarity could occur as an abrupt change, a periodic variability, or a long-term trend.

to rainfall/runoff methods because they are based directly on observed streamflow measurements. Various AEPs can be derived and graphed from these measurements, as represented by a flood frequency curve.

HEC-17 calls for the designer to consider a range of possible discharge values, especially for assets that are to remain in service for longer than 30 years. Later under step 3 in chapter 7, HEC-17 uses the upper 90 percent confidence limit from historical precipitation records to determine whether future precipitation projections from climate models should be weighted more heavily in the design. If the future precipitation projections are not deemed significantly different from the historical observations, design decisions can be made based on the historical observation dataset. HEC-17 still advises the designer to consider the uncertainty associated with the historical observations, especially with

Trends in Annual Peak Streamflow

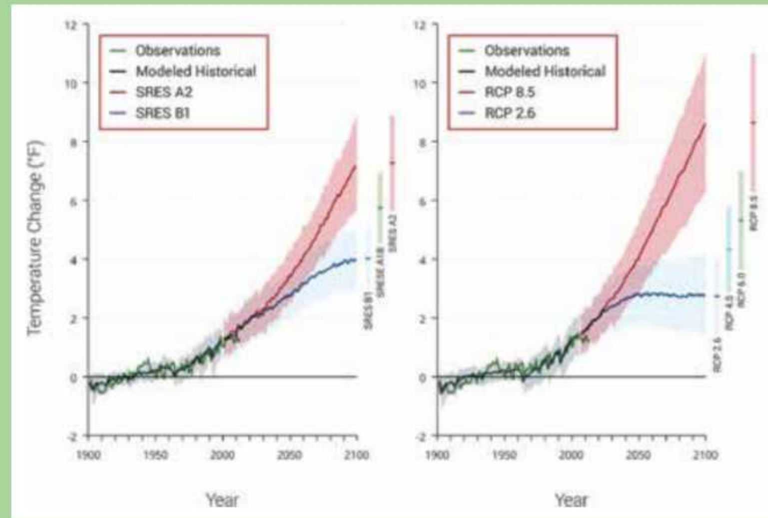


Streamgages with positive trends are shown by upward-pointing triangles and those with negative trends are shown by downward-pointing triangles. Dots represent gages with no significant trends. There are no regions of the country showing consistent trends. *Source: USGS.*

An abrupt change might be due to a wildfire scorching a watershed. A periodic variability might be a multiyear weather oscillation such as the El Niño–Southern Oscillation or ENSO. A long-term trend could be a change in precipitation patterns, which climate models project to increase in the northern latitudes of the United States. Sometimes a long-term trend can be masked by periodic variabilities.

The fourth chapter provides information on how to statistically detect significant gradual and abrupt trends and how to adjust a project's design for these trends. Chapter 4 also warns readers to be careful when calling something a trend. The length of record being considered could determine whether a trend is significant or just an intermediate fluctuation.

Emissions Scenarios



These two graphs compare GCM output for temperature change for selected (1) special report on emissions scenarios (SRES) and (2) representative concentration pathway (RCP) scenarios. Some of the scenarios are more severe than others. HEC-17 recommends looking at scenarios of RCP 6.0 and greater, especially for long-lived, critical assets. *Source: FHWA.*

Climate Modeling

Chapter 5 covers global climate models (GCMs), emissions scenarios that drive the GCMs, and downscaling of the GCM outputs to make them more useful in transportation design. Global climate models are sophisticated computer models used to represent atmospheric physics and the connections between the Earth's atmosphere, land surface, sea surface, and polar ice.

By design, GCMs operate on large spatial and temporal scales and are useful at modeling long-term trends of average global temperature and, to a lesser extent, precipitation changes. Many GCMs have been developed worldwide and run on different assumptions and formulations to simulate atmospheric processes. GCM outputs are called "projections" and are commonly expressed as future estimates of daily precipitation and minimum and maximum daily temperatures. Climate scientists often examine outputs from multiple GCMs or an "ensemble" of models, in order to account for the range of possible results.

Because global climate models are designed to model atmospheric conditions for the entire planet, their computational grid cells are large, usually between 120 to 190 miles (193 to 306 kilometers) per side. In order to be useful at a transportation design scale, one of two types of downscaling is used to break the cells into smaller units. Dynamic downscaling uses a smaller regional climate model that is nested within a larger climate model. Statistical downscaling uses statistics to relate the GCM outputs to historical measurements of temperature and precipitation.

FHWA recommends retrieving statistically downscaled climate projections at the "Downscaled Climate and Hydrology Projections" (DCHP) Web site, http://gdo-dcp.ucllnl.org/downscaled_cmip_projections. Instructions for retrieving these data are contained in FHWA's CMIP Tool (see www.fhwa.dot.gov/environment/sustainability/resilience/tools). CMIP refers to the World Climate Research Programme's Coupled Model Intercomparison Project, which shares, compares, and analyzes the latest outcomes of GCMs. Grid cells from the DCHP site are 7.5 miles (12 kilometers) per side, which will better account for local variations in temperature and precipitation, such as between a valley and a mountainous ridge.

Risk and Resilience

Although many definitions of risk can be found, they all involve the consequences associated with hazards (including climatic) and the probabilities of those hazards occurring. Design criteria or standards are based on a community's tolerance for risk. Critical roads such as interstate highways will have lower tolerance for risk than collector system roads with less traffic. Consequences can be in the form of loss of life, physical damage to the infrastructure, or interruption of service requiring detours.

The manual's sixth chapter discusses the expected performance of an asset over its design life. An example would be that the probability of a 50-year storm striking within a 75-year design life is 78 percent. The longer the design life (say 100 years), the higher the probability of that 50-year storm occurring (now 87 percent).

Risk may change over the lifetime of an asset, especially if the asset is located in a watershed that is experiencing nonstationarity caused by changes in precipitation patterns or land use changes in the watershed itself. Consider the case of a watershed where the calculated magnitude of the 2 percent AEP flood is 1,000 cubic feet (28 cubic meters) per second today, but in the future the 2 percent AEP may be 1,200 cubic feet (34 cubic meters) per second. This case demonstrates the need to consider nonstationary

Probability of Storm Occurrence

This chart shows the probability of occurrence as a function of return period, T, and years of service. There is an 87-percent chance that a 50-year return period storm (green dashed line) will occur within a 100-year service life. *Source: FHWA.*

changes seriously if a critical asset is expected to withstand higher flows long into the future.

Chapter 6 also recommends that the designer look at a range of possible storm events based on the statistical uncertainties described in chapter 4 and based on a range of emissions scenarios and ensembles of multiple datasets of downscaled climate model projections. The designer then needs to examine the consequences of particular flow events within that range. Those consequences, or that risk, may change over time. The designer also needs to judge how resilient that asset is to the range of possible flows. A resilient asset, such as a culvert or bridge, will be able to pass the design event without serious consequences.

"Resilience" is defined as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions. A culvert may be more resilient if it is under a deep roadway fill, where it might take more flow to overtop and damage the roadway. This culvert might still suffer consequences, such as damage to the roadway embankment, flooding of upstream properties, and erosion at the culvert outfall, but it might perform better than a culvert under a shallow fill where an equivalent flow may wash out the roadway section entirely.

Moving Stepwise Toward A More Resilient Design

As mentioned earlier, chapter 7 is the heart of the manual. This chapter provides a straightforward framework or procedure to look at an existing hydrologic design and systematically incorporate downscaled climate projections, based on the criticality and design life of the asset, and the significance of the nonstationary trend in the climate.

The framework consists of five levels of analysis, ranging from traditional hydrologic design to sophisticated, specialized analyses, including downscaled climate projections. At the conclusion of each level, the designers evaluate whether they are comfortable with the level of risk determined for the asset, or whether they need to move ahead and further examine the significance of climate impacts on the asset.

The chapter also includes information on the types of hydrologic tools and methods that may be appropriate for different levels of analysis, recommendations on confidence intervals to examine for different

Shown is a flooded road in North Carolina. This road could be raised to possibly increase its resilience. *Photo: © NikonShutterman, Getty Images.*

lengths of design life, and even advice on the composition and skill sets of the members of the design team.

In addition, the chapter talks about programmatic information that results from formal large-scale climate studies performed within a State or vetted by its DOT. This programmatic information can help the agency make broad policy decisions as to how to assess risk and incorporate resilience into projects within the State and when projects warrant a higher level of climate analysis. This information also would also provide designers with standardized, easy-to-use methods to include local climate projections into their projects.

The five levels of analysis are discussed in detail in chapter 7:

Level 1—Historical discharges. At level 1, the design team applies standard hydrologic design techniques based on historical data to estimate the design discharge. In addition, the team qualitatively considers changes in the estimated design discharge based on possible future changes in land use (runoff coefficient) and climate. Note that no climate projection data are required for this level. This step could be as simple as making sure that the latest hydrologic observations are used in the design.

Level 2—Historical discharges/confidence limits. Here, the design team estimates the design discharge based on historical data and qualitatively considers future changes in land use and climate, as in level 1. In addition, the design team quantitatively estimates a range of discharges (confidence limits) based on historical data to evaluate the performance of a plan or project. Again, no climate projection data are required, but a designer might consider a higher magnitude event (above the design event) within the range of the confidence limits.

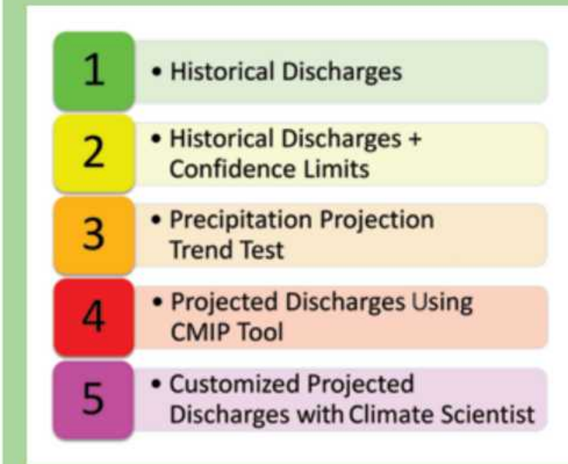
Level 3—Historical discharges/confidence limits with precipitation projections. At level 3, the design team performs all level 2 analyses and quantitatively estimates projected changes in precipitation for the project location. The team evaluates the projected precipitation changes to determine whether a higher level of analysis is appropriate. This level is really just a test to determine whether the change in projected precipitation because of a changing climate is large, as compared to the uncertainty in the current observed data (as represented by the upper 90 percent confidence limit). If the change is large, move on to level 4. This level requires obtaining downscaled climate projections, preferably from the DCHP Web site.

Level 4—Projected discharges/confidence limits. At level 4, the team completes all level 3 analyses and develops projected land use and climate data, where feasible. The team performs hydrologic modeling using the projected land use and climate data to estimate projected design discharges and confidence limits. Downscaled climate projections are required and are used to evaluate the design. Consultation from experts in climate science is recommended but not required.

Level 5—Projected discharges/confidence limits with expanded evaluation. Here, the design team performs the equivalent of the level 4 analyses based on customized projections of land use and climate. The team also expands to include appropriate expertise in climate science and/or land use planning to secure site-specific custom projections.

Examples of the levels summarized above can be found in chapter 8 and were also provided in the HEC-17 webinars.

Five Levels of Analysis



The five levels of analysis range from traditional hydrologic design to sophisticated specialized analyses that include downscaled climate projections. *Source: FHWA.*

HEC-17 Webinars

In early 2017, FHWA produced a series of three webinars outlining the HEC-17 manual in detail, including stepping through an example involving the design of headwater elevation for a culvert, using three of the five levels of analysis. A culvert example from the webinar shows results progressing from the single flow calculated in level 1, to the range bounded by confidence limits in level 2, to a further expanded range considering climate projections in level 4.

Where Do We Go From Here?

Chapter 8 contains examples of analyses performed by various State DOTs and categorized in HEC-17 as examples of various levels of analysis. The chapter on these projects also contains commentary highlighting good practices and lessons learned.

The projects range from a level 2 bridge analysis in Connecticut to a sophisticated level 5 analysis of six bridges in two watersheds in Iowa. The Iowa examples used a continuous daily simulation of rainfall from customized, downscaled climate projections developed at Iowa State University and a complex watershed model developed at the University of Iowa. This project was featured as one of the FHWA resiliency pilots, which can be found at www.fhwa.dot.gov/environment/sustainability/resilience/pilots.

Climate science continues to progress as global climate models become faster and more comprehensive. Downscaling techniques and datasets included on the DCHP Web site continue to improve. Also, floodplain regulations continue to evolve as local, State, and Federal governments struggle with how

Level 1: Traditional Hydrologic Design

Level 2: Confidence Limits

Level 4: Expanded Confidence Limits

During the webinars, this example of designing headwater elevation for a culvert used three of the five levels of analysis from the HEC-17 manual: Level 1 (traditional hydrologic design), Level 2 (consideration of confidence limits), and Level 4 (expanded confidence limits after incorporation of climate projections). *Source: FHWA.*

to build resilient infrastructure and deal with extreme events and their impacts on U.S. society.

FHWA is participating in several research efforts with science agencies, including the U.S. Geological Survey and NOAA, to better refine the agency's guidance in this field. In addition, the National Cooperative Highway Research Program's Project 15-61, "Applying Climate Change Information to Hydrologic and Hydraulic Design of Transportation Infrastructure," is a major research effort involving a multiagency panel of State DOT hydraulic engineers, planners, climate scientists, and hydrologists.

In 2018, FHWA will turn its attention back to coastal highways, updating and expanding the companion coastal hydrology circular HEC-25. When this is completed, most of the research listed above will be ready to be incorporated into a third edition of HEC-17. Recent extreme events such as Hurricane Harvey in the Houston, TX, area highlight the need for more resilient future highway infrastructure investments to be made considering possible changes in precipitation patterns as well as land use changes occurring in surrounding watersheds. HEC-17 provides a scientifically informed, comprehensive, and balanced approach to designing for future uncertainties.

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For more information, see www.fhwa.dot.gov/engineering/hydraulics/pubs/hif16018.pdf or contact Brian Beucler at 202–366–4598 or brian.beucler@dot.gov. The recorded webinar series on HEC-17 can be found at www.fhwa.dot.gov/engineering/hydraulics/media.cfm.

Along the Road

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

Technical News

FHWA Launches Safety Microsite

In May 2017, the Federal Highway Administration launched a microsite on the agency's Web site to provide a central resource for information about guardrails and other roadside safety hardware. The new site is the latest in an ongoing effort to emphasize the importance of, and improve accessibility to, State guardrail data—including preliminary data from an In-Service Performance Evaluation pilot program.

Notably, the site makes it possible for State departments of transportation to share data about in-service performance of roadside hardware. The site hosts a growing collection of findings from the States in response to interest about performance guardrail terminals.

The site highlights FHWA's In-Service Performance Evaluation pilot, which began in 2015 and will continue through 2019. The project is being conducted jointly with California, Massachusetts, Missouri, and Pennsylvania to find better ways to collect in-service performance data of roadside hardware.

The In-Service Performance Evaluation pilot aims to improve roadway safety by making it easier for States to uniformly collect performance data on guardrails.

For more information, visit https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/guardrail_ispe.cfm.

Public Information and Information Exchange

Cambridge Science Festival Held at Volpe Center

Science lovers of all ages gathered in April at USDOT's Volpe National Transportation Systems Center in Massachusetts to attend transportation events as part of the Cambridge Science Festival. The festival is an annual 10-day event that engages an estimated 100,000 people with science, technology, engineering, and math (STEM). This was Volpe's third year participating in the festival as part of its growing STEM outreach efforts in the local community.

On April 17 and 19, 2017, Volpe hosted three events as part of the Cambridge Science Festival.

Making Places: Building with Blocks invited children ages 5 to 9 to learn about the world of transportation planning. Children engaged in a "place making" activity where they learned about the things that go—such as trains, buses, and bicycles—in different types of places, from cities to neighborhoods to farms. Then, students worked in groups to bring their ideas to life using blocks.

Volpe Center

Children ages 5 to 9 learned about the world of transportation planning and brought their ideas to life using blocks during Volpe's events as part of the Cambridge Science Festival in April 2017.

At the end, they presented their models to the other students and to Volpe's transportation planners.

MoveCity: Designing a City that Moves You asked middle school and high school students to become transportation planners for the day. Students engaged in a mock charrette and designed their own cities, including multimodal transportation systems that welcomed skateboard routes and hoverboard lanes. The students collaborated in teams with professional transportation planners and worked through zoning and permitting before presenting their MoveCities.

Vople Talks featured five short talks from Volpe employees who are working on important transportation issues such as work zone safety, alternative jet fuel, and distracted driving. The event was well attended by students, scientists, and members of the general public. After the talks, guests took a tour of the Volpe Center's Boeing 737 flight deck simulator, custom-built driving simulator, and locomotive simulator.

Volpe Center

FHWA Releases Latest Construction Cost Index

FHWA recently released the first National Highway Construction Cost Index (NHCCI) published since the agency made major methodological revisions to improve its accuracy. Now called "NHCCI 2.0," the index is a quarterly estimate of the rising cost of domestic highway construction and maintenance over time.

NHCCI 2.0 is the first major revision since FHWA created this index in 2007, and reflects steadily rising costs of highway construction and repair. Though the data fluctuate slightly each quarter because of a variety of factors, including market conditions, labor supply, materials costs, and inflation, the figures show that highway construction costs today have climbed by 68 percent compared to similar costs in 2003.

Such information is of critical importance to national transportation decisionmakers, who rely on forecasts and

cost estimates to ensure sufficient financial support for the Nation's transportation needs.

As measured by the Bureau of Labor Statistics, key highway components such as asphalt, concrete, and metal grew at 107 percent, 61 percent, and 45 percent, respectively, between 2003 and 2016.

Many States track their own construction costs, with some experiencing much higher inflation than others. For example, California's composite cost index increased by 143 percent between 2003 and 2016, while Texas' increased by 122 percent over the same period.

For more information, visit www.fhwa.dot.gov /policyinformation/nhcci/pt1.cfm.

Alaska Federal Lands Updates Transportation Plan

Over the past several years, Federal lands management agencies have developed long-range transportation plans (LRTPs). These LRTPs are policy-level plans that help agencies navigate transportation funding and management decisions over the next 20 years. LRTPs require periodic updates to reflect current conditions. Currently, work is underway to develop the first LRTP update for Federal lands in Alaska.

The update to the Alaska Federal Lands Collaborative LRTP will be the first such update for a Federal lands management agency. The original Alaska Federal Lands LRTP, completed in 2012, was a pioneering effort to develop the first multiagency LRTP for Federal lands. It was a collaborative endeavor between six agencies, including the Alaska Department of Transportation & Public Facilities, and led by FHWA's Western Federal Lands Highway Division.

FHWA is managing the multiagency update with USDOT's Volpe Center supporting the effort by researching existing conditions, advancing performance management, and conducting financial analyses of available funds, needs, and gaps based on available data from each agency. The Volpe Center will also develop the updated content for publication.

The update will reflect new requirements and funding opportunities in the 2015 Fixing America's Surface Transportation (FAST) Act, as well as other national guidance for Federal lands management agencies. It will incorporate updated data, report on accomplishments since the 2012 plan, and build on the team's progress to develop performance measures and monitoring systems. The Alaska Federal Lands LRTP update is expected to be complete by December 2018.

In addition, as part of the update, the multiagency team will document their process to provide a template for other Federal lands management agencies to follow when updating their LRTPs.

Volpe Center

Minnesota and Wisconsin Open St. Croix Crossing

Minnesota Governor Mark Dayton and Wisconsin Governor Scott Walker recently cut the ribbon on the long-awaited St. Croix Crossing project. The $646 million effort, which began in 2012, connects the city of Oak Park Heights, MN, to the town of St. Joseph, WI. It spans the St. Croix River with a more than 5,000-foot (1,524-meter) bridge that will carry four lanes of traffic in each direction.

Minnesota DOT

This aerial view looking west toward Minnesota shows the St. Croix Crossing in June 2017, near the end of construction.

The project replaces the Stillwater Lift Bridge, which was dedicated more than 80 years ago. Since it opened, the Lift Bridge carried thousands of motorists between the two States on Minnesota Highway 36 and Wisconsin Highway 64. Over the years, as traffic increased, travelers faced mounting delays from congestion because the bridge periodically needs to lift to accommodate boat traffic on the St. Croix River. Although the bridge is currently closed to vehicle traffic, it continues to lift daily to allow water traffic to pass below.

The new bridge, about a mile (1.6 kilometers) downstream from the Lift Bridge, is designed to carry more than twice the 18,000 vehicles a day that crossed the river on the Lift Bridge. The St. Croix Crossing is 100 feet (30 meters) wide and rises between 110 feet (34 meters) and 150 feet (46 meters) above the water, enabling boat traffic to freely move beneath it.

The bridge is a hybrid design structure combining a cable-stayed build with a segmented concrete box design. Planners chose the hybrid design to ensure that the pier heights, which are 65 feet (20 meters) above the bridge surface, would not be higher than the bluffs along the river. It is intended to fit into the river gorge as naturally as possible.

For more information, visit www.dot.state.mn.us /stcroixcrossing.

Minnesota DOT

ODOT Launches Distracted Driving Campaign

Nearly 500 people lost their lives on Oregon roads in 2016, and crash data analysis points to a contributing cause: distracted driving. Every 3 hours someone is injured by a distracted driver in Oregon.

Through a campaign launched in September, the Oregon Department of Transportation (ODOT) aims to help reduce distracted driving by making healthy driving a competition. The department and its partners, AAA of

ODOT

Oregon/Idaho and the Oregon State Police, invite those who drive in Oregon to join the movement toward healthy driving at www.drivehealthy.org.

The concept is simple. Groups of Oregonians band together to compete with others to see who can keep their phones locked while driving: school against school, Rotary Club against the Kiwanis, one church challenges another across town. The free app shows the top scorers in each category, plus an organization's monthly score.

The campaign comes as the result of the recommendations from a statewide task force convened in 2016. The task force recommended taking a positive approach to the problem.

Organizations can register on the competition Web site then download the app. Each month is a new opportunity to compete. Will it be effective? A recent, similar campaign in Boston reduced distracted driving by 47 percent.

The campaign also encourages local advocates to help reduce distracted driving in their communities.

For more information, visit www.drivehealthy.org.

ODOT

Arizona Installs First Prefabricated Bridge

In March 2017, Arizona constructed the State's first prefabricated bridge over the Sacramento Wash along historic Route 66. The at-grade wash encompasses a large watershed near Topock, AZ, and is notorious for flooding the highway.

The rural two-lane road flooded 33 days during a 2-year period, causing a 24-mile (39-kilometer) detour each time and costing motorists an estimated $33,000 a day.

To address the problem, Mohave County partnered with the Arizona Department of Transportation (ADOT) to install a bridge over the wash to raise the road's

ADOT

Workers lower a section of Arizona's first prefabricated bridge into place over the Sacramento Wash near Topock, AZ.

profile by 10 feet (3 meters). Design work began in February 2016 and construction started with bridge placement in March 2017. The 114-foot (35-meter) bridge was fabricated in Phoenix and transported in sections to the site nearly 4 hours away.

Engineers planned for a 4-day (96-hour) road closure, but crews completed the project in 87 hours. A typical accelerated bridge replacement project often can be done faster, but because this was a new bridge, the contractor also had to construct the approaches. The actual bridge construction time was about 30 hours. Conventional bridge construction would have required an 11-week closure.

ADOT

Reporting Changes of Address

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Lisa A. Shuler, Editor-in-Chief — August 8, 2017

Internet Watch

By Steve Sill

New Framework for ITS and Connected Vehicles

Effective intelligent transportation systems (ITS) architectures can facilitate efficient and interoperable ITS deployments. The U.S. National ITS Reference Architecture and associated toolsets provide a definitive and consistent framework to guide the planning and deployment of ITS.

ITS architecture helps jurisdictions cooperate and harness the benefits of regional and cross-regional approaches to transportation challenges while enabling regional customization. Recent advances in technology, such as connected and automated vehicles, have made reference architecture more important than ever.

The U.S. Department of Transportation's ITS Program recently released the first version of the ITS national reference architecture to fully incorporate connected vehicle capabilities in detail. The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) provides a unifying framework that covers ITS comprehensively, including connected vehicle and "traditional" infrastructure ITS capabilities.

ARC-IT and the accompanying toolsets help implementers develop regional architectures to effectively meet their needs and assure regulatory compliance while facilitating efficient, secure interoperable ITS deployments. All of the ARC-IT content, including tools and training, is available at www.arc-it.net.

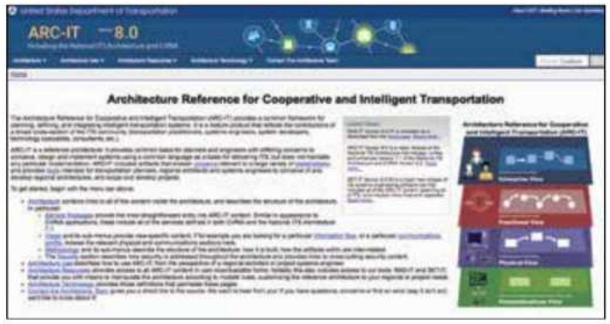
"With the emergence of connected vehicle technologies, interoperability has become essential, rather than merely beneficial," says Kingsley Azubike with FHWA's Office of Operations, whose program supports the ITS architecture. "The newly released integrated architecture supports efficient nationwide ITS deployment and interoperability."

What's So Different?

ARC-IT is version 8 of the National ITS Architecture. The National ITS Architecture was initiated in the 1990s to identify interfaces for standardization and address all of the original ITS user services into one common framework. That architecture framework has been continually updated to keep pace with stakeholder needs and expectations along with rapid technological evolution. The last update to the ITS reference architecture in 2015 (version 7.1) has been widely used as the basis for regional ITS architectures around the country. Concurrently, USDOT developed a separate Connected Vehicle Reference Implementation Architecture (CVRIA) to capture the connected vehicle research efforts into a single reference architecture.

ARC-IT version 8 continues the evolution of the National ITS Architecture by merging connected vehicle concepts and a new structure to address more stakeholder concerns.

ARC-IT includes a set of interconnected components that are organized into four views that focus on different architecture perspectives: enterprise, functional, physical, and communications. The hyperlinked nature of the



ARC-IT Web site enables a user to start with any of these views, however, most users start with service packages. Service packages provide a slice of the physical view that address specific services like surface street control.

Users can easily navigate from component to component to find what they need. This interconnected presentation of the ARC-IT content is possible because of the traceability that is maintained between each of the architecture components.

The ITS Architecture Program will continue to work to improve ARC-IT and keep pace with changing technology and the evolution of stakeholder needs. In the near term, USDOT expects to introduce additional enterprise layer functionality and toolset features in version 8.1.

Tools and Training Available

ARC-IT also includes the release of two companion software tools. The Regional Architecture Development for Intelligent Transportation (RAD-IT) provides all of the functionality that regional architects have come to expect from Turbo Architecture, a previous tool, updated with a more modern user interface and using the ARC-IT database. The Systems Engineering Tool for Intelligent Transportation (SET-IT) provides related project architecture functionality tailored to the implementation and project specification.

Training is also available. The training page on the Web site provides a listing of online courses that walk through the ARC-IT Web site and how to use it as well as the software tools, RAD-IT, and SET-IT. FHWA also has a number of workshops and instructor-led courses to help regions work together to develop and make better use of their regional architectures as well as to apply the systems engineering process to ITS.

"We're now starting to get more questions and interest in connected vehicles," says FHWA's Azubike. "Fortunately, ARC-IT with the toolsets, and the available training and workshops, provide the support to help agencies continue to expand their ITS while providing a way to consider new technologies such as connected vehicles."

For more information, visit www.arc-it.net or contact Steve Sill at steve.sill@dot.gov.

Steve Sill is a program manager in USDOT's ITS Joint Program Office.

NATIONAL HIGHWAY INSTITUTE

Training Update

by Judy Francis

New Transportation Performance Management Training

Transportation officials and policymakers have access to lots of data to help plan and implement transportation services. But how do they best use the data to measure performance and improve transportation systems? Transportation performance management (TPM) is a strategic approach that uses system information to make investment and policy decisions to achieve performance goals.

The National Highway Institute (NHI) offers TPM training based on the latest technologies, best practices, and industry advancements. NHI offers instructor-led training sessions in all 50 States to help transportation professionals reach their professional development goals. Check out NHI's TPM courses below, and visit the online course catalog to see more training options and formats across NHI's 18 program areas.

Performance Management Courses

Transportation Performance Management Overview for the MAP-21 and FAST Acts (course number 138004). This 1-day training presents an overview of the TPM provisions of the Moving Ahead for Progress in the 21st Century (MAP-21) and Fixing America's Surface Transportation (FAST) Acts. It describes the responsibilities of agencies in delivering these requirements, highlights the importance of data in meeting the performance management provisions, and captures proven, noteworthy practices to help agencies get started. This course enables participants to interact with and learn from peers through open discussion.

Transportation Performance Management for Safety (course number 138006). This 2-day course explains the safety performance measures and noteworthy practices for States to adopt to comply with requirements of the MAP-21 and FAST Acts. It provides participants with an understanding of the data needed to meet the safety TPM requirements and recommends an evidence-based and data-driven methodology for setting safety targets. The course helps improve States' ability to coordinate target setting between the State departments of transportation and the State Highway Safety Office, as well as between the State DOT and the State's metropolitan planning organizations (MPOs). The course reviews crash data trends through hands-on exercises and establishing safety targets based on planned safety programs, external factors, and countermeasure deployment. Throughout the course, participants also practice evaluating resource allocation and safety program performance to inform future target-setting efforts.

Performance-based Planning and Programming (course number 138007). Another 2-day training, this course aims to familiarize transportation agencies with key elements of a framework for performance-based planning and programming, how the framework supports TPM, and how these framework elements relate to the requirements for transportation planning and transportation system performance. NHI recommends this course for transportation professionals at State DOTs, MPOs, regional planning organizations, transit agencies, and USDOT who are responsible for developing and implementing performance-based plans and programs, and for those who are responsible for integrating and linking related requirements. Participants should have knowledge of the planning process and the collaboration needed for it.

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Effective TPM uses system information to make investment and policy decisions and achieve national performance goals.

The Role of Data in Transportation Performance Management (course number 138011). In this 2-day training, participants learn how to manage, analyze, integrate, and use data from diverse sources to meet agency and performance goals. Participants also learn how to improve their data programs to support specific targets and use data to meet the TPM requirements of 23 CFR 490: National Performance Management Measures and the related MAP-21 and FAST Acts.

Steps to Effective Target Setting for Transportation Performance Management (course number 138012). MAP-21 requires State DOTs, MPOs, and public transit providers to set performance targets for USDOT's established national performance measures. This 2-day training explains the elements of target setting for TPM and focuses on how to set reasonable, attainable goals.

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

Judy Francis is a contracted marketing analyst for NHI.

Communication Product Updates

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

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

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

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).

Analytical Method to Measure Water in Asphalt and Its Application to Emulsion Residue Recovery (TechBrief)
Publication Number: FHWA-HRT-15-056

This technical brief presents researchers' observations that excess water in asphalt binders and pavement mixes can have a deleterious effect on pavement performance. The addition of water to binders through using warm and cold mix technologies highlights the need for accurately measuring water in asphalt. Also, increased water content of biologically derived binders and oils may be responsible for compatibility issues with petroleum-based products.

The document discusses how researchers developed a Karl Fischer titration method for quantifying water in asphalt and asphalt emulsions that is accurate, quick, and highly sensitive. The method's detection limit is approximately 100 parts per million (ppm). Researchers tested Strategic Highway Research Program binders to assess the effectiveness of the method, applying the method in the evaluation of three emulsion recovery procedures.

Binder films and emulsion residue films treated in a 100-percent humidity environment at 60 degrees Celsius (140 degrees Fahrenheit) showed a maximum of 1,500 ppm water and generally contained approximately 200 ppm more water than nonhumidity-treated films. Using the Karl Fischer titration method, researchers evaluated the method of quantifying water in emulsion residues by heating the residues at 135 degrees Celsius (275 degrees Fahrenheit) until constant mass is obtained—meaning the liquid material has evaporated—and calculating water content by mass loss after evaporation. They found that some residues may contain volatile material other than water that is evaporated at 135 degrees Celsius (275 degrees Fahrenheit), yielding artificially elevated and inaccurate water content measurements by the mass loss method.

This document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/pavements/15056/index.cfm.

Leveraging the Second Strategic Highway Research Program Naturalistic Driving Study: Examining Driver Behavior When Entering Rural High-Speed Intersections (Report)
Publication Number: FHWA-HRT-17-016

Intersections, particularly stop-controlled intersections in rural areas, are the locations of a significant number of traffic crashes. Factors that contribute to these crashes include inadequate surveillance, failure to obey/yield, driver inattention, and speed.

This research study examines stopping and scanning behavior as drivers approached and entered rural high-speed intersections, producing actionable insights into transportation safety by leveraging the second Strategic Highway Research Program (SHRP2) safety databases.

Researchers found that brake distance was sufficiently predicted by brake speed (the speed at which the driver was moving upon initial brake activation). Researchers determined that the probability of making a complete

stop varied significantly with average annual mileage and expressed risk associated with performing rolling stops. Participants with higher average annual mileage were more likely to make complete stops.

The research team divided intersection approaches into five segments, and analyzed total glance duration in eight regions of interest within each segment. Researchers found a noteworthy difference among intersection crossings according to the type of stop performed. Drivers who came to a complete stop spent just 39.2 percent of their prestop time scanning the intersection, while rolling stoppers spent 74.5 percent. This suggests that complete stoppers focus on getting to the intersection and then stop, scan, and proceed, whereas rolling stoppers scan the intersection prior to arrival so that they can proceed at higher speeds while maintaining a perception of safety.

This report details the SHRP2 data acquisition process, exploratory analysis, and results. It is available to download at www.fhwa.dot.gov/publications/research/safety/17016/index.cfm.

Cooperative Adaptive Cruise Control Human Factors Study: Experiment 4—Preferred Following Distance and Performance in an Emergency Event (Report)
Publication Number: FHWA-HRT-17-024

This report describes the fourth and final experiment in a series of four studies that explore cooperative adaptive cruise control (CACC), which combines three driver assist systems: (1) conventional cruise control, which automatically maintains the speed a driver has set; (2) adaptive cruise control, which uses sensors to automatically maintain a gap the driver has selected between the driver's vehicle and a slower-moving vehicle ahead; and (3) dedicated short-range communications to transmit and receive data with surrounding vehicles so that the cruise control system can more quickly respond to changes and speed and location of other CACC vehicles (including vehicles that the driver cannot see).

When using CACC, drivers share vehicle control with an automated system that includes vehicle-to-vehicle and vehicle-to-infrastructure communications. Communications between nearby CACC-equipped vehicles will enable automated coordination and adjustment of longitudinal control through throttle and brake activations. Automated control should enable CACC-equipped vehicles to safely travel with smaller gaps between vehicles than drivers could safely manage on their own. Smaller gaps should subsequently increase the roadway capacity without increasing the physical amount of roadway. However, shorter following gaps lead to problematic human factors issues.

This report presents human factors research to examine the effects of CACC on driver performance in a variety of situations. The findings support the idea that performance depends more on overall CACC following distance settings than with drivers' personal preferences. This will enable CACC systems to implement a single following distance gap (or set of gaps based on vehicle physics). The results show that it is critical that drivers receive clear alerts when it is necessary to take over control of the vehicle. Without such measures, it is possible that CACC implementation may not result in improved roadway safety.

This report is available to download at www.fhwa.dot.gov/publications/research/safety/17024/index.cfm.

FHWA Research and Technology Evaluation: Gusset Plates Final Report (Report)
Publication Number: FHWA-HRT-17-039

After the I-35W Mississippi River Bridge in Minneapolis, MN, collapsed in 2007, the National Transportation Safety Board (NTSB) issued recommendations to FHWA and the American Association of State Highway and Transportation Officials (AASHTO) to prevent similar catastrophic bridge failures. An FHWA research project to assess the performance and design of steel gusset plate connections facilitated actions that addressed one of the final NTSB recommendations.

As part of the FHWA research and technology program evaluation, FHWA decided to evaluate the gusset plate project to better understand how FHWA's investment in gusset plate research has affected the design and rating of gusset plates. This report documents the findings of a summative evaluation of the project. The report focuses on outcomes resulting from collaboration between FHWA and NTSB. Data collection for the evaluation relied primarily on telephone interviews with stakeholders, as well as document searches and reviews.

This evaluation focused on processes FHWA used to develop the National Cooperative Highway Research Program Project 12-84 following the I-35W bridge collapse. Strong relationships and a commitment to safety among FHWA, NTSB, and AASHTO are apparent in the timeline leading up to the publication of the final report and in discussions the evaluation team held with stakeholders.

The evaluation team determined that FHWA provided vital support to NTSB to determine the cause of the bridge collapse, assisted NTSB's process for choosing a final safety recommendation, expedited research underlying the publication of results, and informed updates to AASHTO specifications. The gusset plate project provided essential knowledge that led to the rapid development of national safety standards that will help prevent other potential gusset plate bridge design failures.

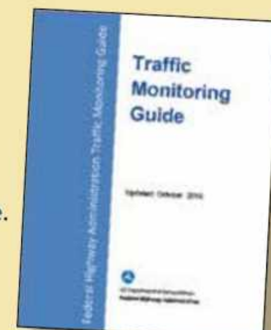
This report is available to download at www.fhwa.dot.gov/publications/research/randt/evaluations/17039/index.cfm.

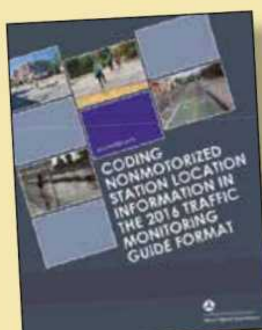
Counting Bicyclists And Pedestrians

The **Traffic Monitoring Analysis System** (TMAS) will begin accepting bicycle and pedestrian counts in early 2018.

State transportation agencies, metropolitan planning organizations, and other agencies may contribute data to TMAS voluntarily. The results will foster research on bicyclist and pedestrian travel and safety, and provide information about travel trends for those modes.

Agencies wishing to submit counts will need to prepare their data in the format specified in chapter 7 of the Federal Highway Administration's 2016 *Traffic Monitoring Guide*, available at www.fhwa.dot.gov/policyinformation/tmguide.





Additional instructions and examples for preparing counts are available at www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/tmg_coding.

For more information or to sign up to contribute counts, please contact Steven Jessberger at steven.jessberger@dot.gov or Jeremy Raw at jeremy.raw@dot.gov.

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