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Federal Highway Administration

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Source: FHWA.

DEPARTMENTS

ABOVE and FRONT and BACK COVERS–Installation of a UHPC overlay on a single lane of the Claiborne Pell Bridge (commonly known as the Newport Bridge) as a part of a UHPC overlay pilot project. The 2-plus mile-long suspension bridge structure spans Narragansett Bay in Rhode Island and is owned by the Rhode Island Turnpike and Bridge Authority. It is the longest suspension bridge in New England.

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

Combating Human Trafficking in Transportation

Here at the U.S. Department of Transportation (USDOT), we take great pride in the capacity of America's transportation network to enable Americans and goods to safely and swiftly get to where they need to go. Unfortunately, human traffickers are also taking advantage of the Nation's transportation systems. To combat these crimes, the Department is utilizing a multipronged approach that reaches Department employees, front-line workers, other transportation stakeholders, and the traveling public.

The fight against human trafficking starts with this Administration taking a whole-of-government approach. USDOT is a member of the President's Interagency Task Force to Monitor and Combat Trafficking in Persons, a Cabinet-level entity chaired by the Secretary of State to coordinate Federal efforts to combat trafficking in persons. Every USDOT employee is required to complete human trafficking awareness training every 3 years so that no matter where our work takes us—from the front doors of headquarters to around the world—we can be informed, aware, and active participants in stopping human trafficking crimes.

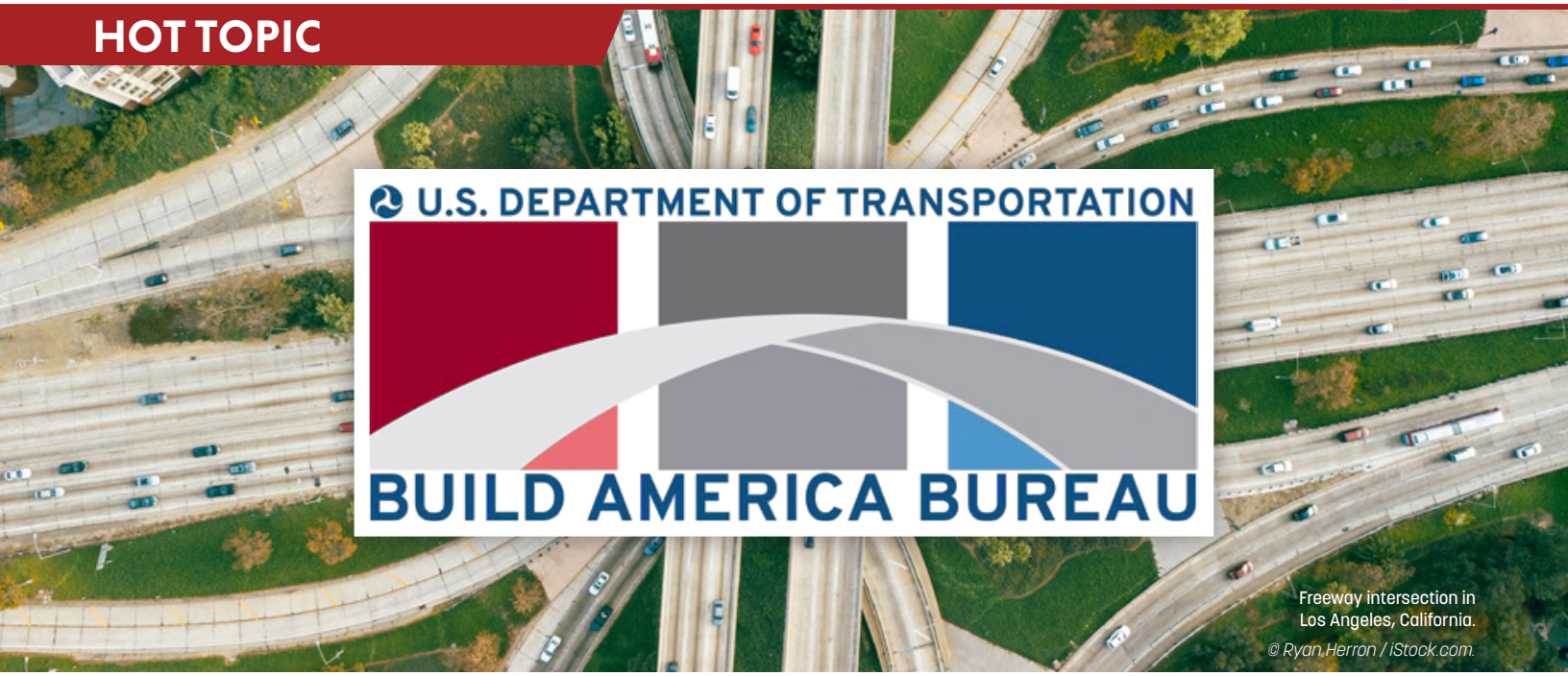
The Department's modal administrations are committed to the fight against human trafficking as well. This year, the Federal Transit Administration awarded $5.4 million to 24 organizations from across the United States to support the prevention of human trafficking and other crimes that may occur on buses, trains, and other forms of public transportation. In 2019, the Federal Motor Carrier Safety Administration issued a final rule that permanently banned drivers convicted of human trafficking from operating a commercial motor vehicle for which a commercial driver's license or a commercial learner's permit is required.

The Department also established a new annual $50,000 Combating Human Trafficking in Transportation Impact Award. As the first recipient of the award, United Against Slavery will conduct a multimodal National Outreach Survey for Transportation, and will make the results available to the public.

We have strong allies across the transportation industry. Earlier this year, I announced the Transportation Leaders Against Human Trafficking "100 Pledges in 100 Days" campaign. I'm proud to say we greatly exceeded even that ambitious goal. More than 500 transportation and industry stakeholders have signed on to join us in combating human trafficking. This initiative includes resources for counter-trafficking strategies, training resources, and public awareness materials to help us maximize our joint impact. USDOT has also partnered with the U.S. Department of Homeland Security for the Blue Lightning Initiative, training more than 100,000 aviation industry personnel from 47 airlines, airports, and other aviation organizations on how to safely identify and report suspected trafficking.

Everyone can make a difference by keeping an eye out for signs of human trafficking. An estimated 24.9 million people worldwide are victims of human trafficking. Survivors have been reported being trafficked through every means of transportation. You can help save the victims by reporting suspected human trafficking to the National Human Trafficking Hotline toll-free at 1-888-373-7888, or by sending the message "info" or "help" via text to 233733 (BEFREE). Every one of us has a role to play in stopping this form of modern-day slavery. To learn more about what USDOT is doing to combat human trafficking, visit *www.transportation.gov/stophumantrafficking*. With your help and our work together, I know we can end human trafficking.

Elaine L. Chao
Secretary
U.S. Department of Transportation



Freeway intersection in Los Angeles, California.
© Ryan.Herron / iStock.com.

Facilitating U.S. Transportation Infrastructure Investment and Innovation

by **PATRICK DECORLA-SOUZA**

Across the United States, transportation agencies at all levels face challenges in funding transportation infrastructure projects. The U.S. Department of Transportation's Build America Bureau can help.

The Build America Bureau is responsible for providing long-term financing for transportation infrastructure projects. Project financing is provided to State or local governments, or to their private partners, for projects delivered under public-private partnership (P3) arrangements. The bureau facilitates investment in projects using innovative financing techniques and alternative project delivery models and can lend to both private and public entities.

Borrowing funds for construction can help combine different phases of a project that would otherwise be stretched out over several years or even decades while awaiting funding. This creates economies of scale and saves on soft costs such as multiple mobilizations and demobilizations, bonding, insurance, and management fees. By shortening construction schedules, borrowing also helps save on inflation costs and minimizes adverse effects of construction-related delays on road users and residents living near the construction site.

Finance methods include funding through the Transportation Infrastructure Finance and Innovation Act (TIFIA) and private activity bonds (PABs).

TIFIA Financing

Numerous P3 and non-P3 projects rely on TIFIA to obtain loans and other forms of credit assistance. Congress enacted TIFIA in 1998 as part of the Transportation Equity Act for the 21st Century (TEA-21). The direct loans provide credit assistance at U.S. Treasury interest rates (or half the U.S. Treasury rate for certain rural projects) with maturities up to 35 years after substantial completion of construction, for up to 33 percent of anticipated project costs. Certain rural projects or those that provide a strong rationale for requiring a higher level of assistance may be eligible to receive TIFIA loans up to 49 percent of anticipated project costs.

PAB Financing

Interest on debt issued by public agencies (municipal debt) is tax-exempt to bond holders. Therefore, public agencies can borrow at a lower cost than private entities. Prior to 2005, one major obstacle to the use of P3s was the inability of the private sector to tap into tax-exempt sources of financing for long-term construction loans, resulting in a higher cost of funds for private sector partners than for a public agency borrowing money for the same project. To compete with conventional public delivery of projects, P3s needed to have access to less expensive credit.

Private activity bonds can address this need. If authorized, a private entity can take advantage of interest rates that are lower because investors are not required to pay taxes on their interest income. This saves on financing costs and reduces project costs for the public sponsor. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) first authorized PABs in 2005. Administered by the Build America Bureau, the program authorizes USDOT to allocate up to $15 billion in tax-exempt PABs for qualified highway and rail-highway freight transfer facilities.

Future Directions

Moving forward under the leadership of its executive director, Dr. Morteza Farajian, the Build America Bureau seeks to target its outreach to borrowers who have not used its programs and to diversify asset classes to include ports, airports, and technology-related projects. The bureau also aims to lend wholesale to State infrastructure banks so that smaller rural projects can benefit from TIFIA, and to provide technical assistance and training to State and local officials on best practices for innovative financing and delivery methods.

For more information, visit *www.transportation.gov/buildamerica*.

PATRICK DECORLA-SOUZA is the program manager for P3 arrangements at USDOT's Build America Bureau and at FHWA's Office of Innovative Program Delivery.

CARMA℠ Research Tracks Explore Opportunities for Transportation System Improvement

The CARMA Program is spearheading research on cooperative driving automation (CDA) concepts poised to transform transportation system performance. FHWA has partnered with ITS JPO, FTA, FMCSA, NHTSA, and MARAD to develop CARMA research tracks that examine CDA impacts to transportation.

CARMA research tracks feature three key focus areas: traffic, reliability, and freight. Each focus area explores a specific application of CDA.

TRAFFIC

Recurring traffic congestion on freeways and arterials, including:

- Congestion
- Transit
- Traffic signals

RELIABILITY

Nonrecurring traffic congestion on freeways and arterials, including:

- Work zones
- Weather
- Traffic incident management

FREIGHT

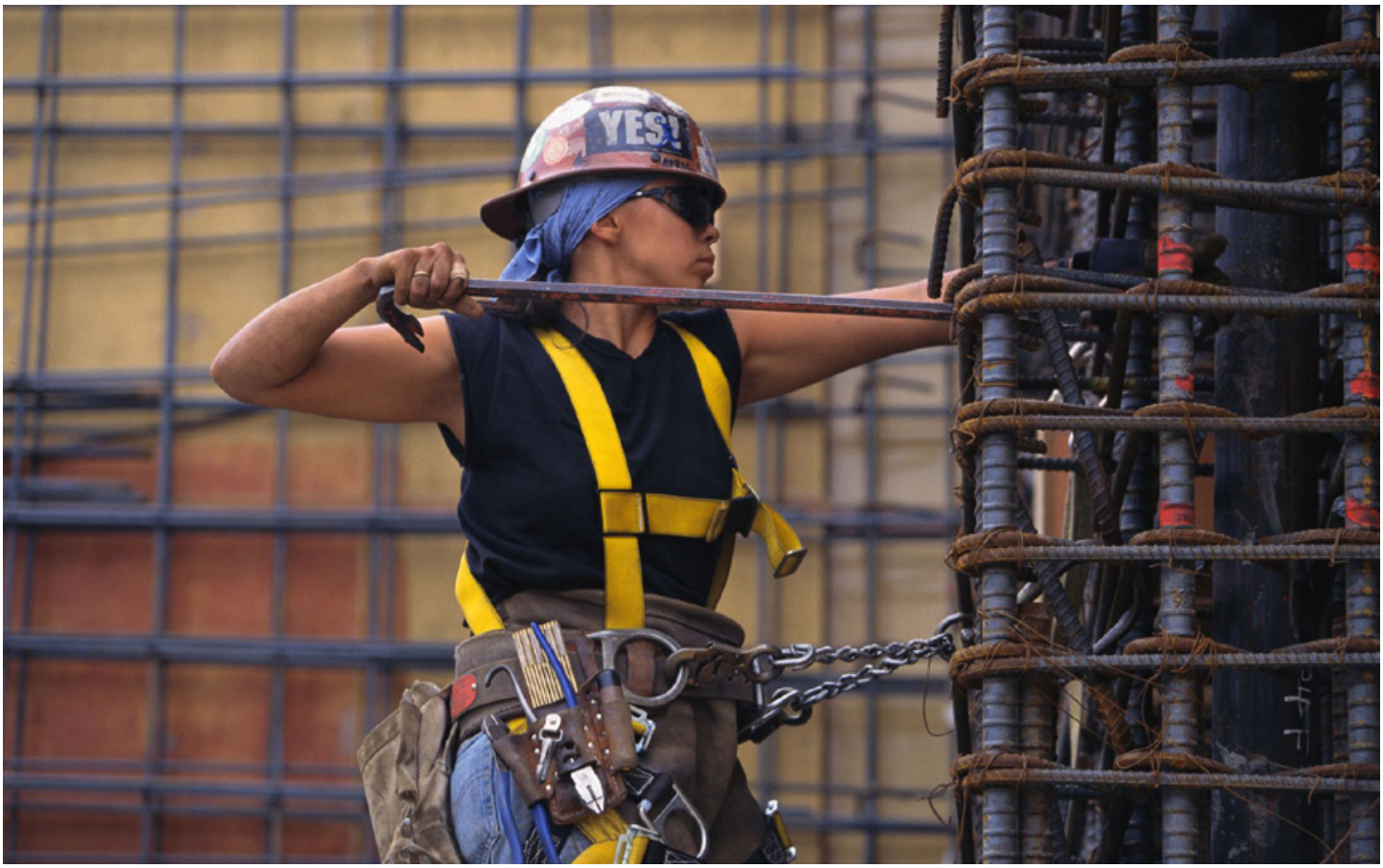
Commercial motor vehicle (CMV) and port operations, including:

- Port drayage
- CMVs
- Truck platooning

CARMA research tracks help uncover opportunities for innovative transportation system improvements to accelerate the development and deployment of CDA.

For more information, visit *https://highways.dot.gov/research/operations/CARMA* or contact Taylor Lochrane at *Taylor.Lochrane@dot.gov*.

CARMA℠



The EDC-6 Strategic Workforce Development initiative promotes strategies and resources to grow the transportation workforce.

© N. Fobes / Getty Images.

Proven Innovations for a Nation on the Move

by **JULIE ZIRLIN**

Which strategies can increase engagement with the people who build and use transportation infrastructure? What products save money on preserving and repairing bridges and roads? How can transportation agencies save time on project delivery and incident management? Innovations that provide solutions for all these and more are highlighted in round six of the Every Day Counts program (EDC-6).

EDC facilitates the deployment of proven but underutilized technologies and processes that, with more widespread adoption and implementation, can enhance safety, accelerate project delivery, reduce congestion, and integrate automation.

Every 2 years, the Federal Highway Administration works with key stakeholder groups to identify a new set of innovations that merit accelerated deployment. After receiving more than 100 suggestions from local, State, and Federal agencies; academia; and industry, and consulting with stakeholders, FHWA selected seven EDC-6 innovations to promote in 2021 and 2022. Each one is timely and relevant to addressing the unique transportation challenges of today.

"Our common goal to enhance our infrastructure, keep America moving, and support economic recovery is why we have themed the next round of EDC—*Innovation for a Nation on the Move*," says FHWA Administrator Nicole R. Nason. "Although the solicitation occurred prior to the national public health emergency, we believe the seven innovations selected for the EDC-6 will continue the legacy of the program and support our efforts as we work toward recovery."

The Power of People

Three of the EDC-6 initiatives actively seek to leverage the power of people in a variety of ways.

Building on the Highway Construction Workforce Partnership, the Strategic Workforce Development initiative promotes strategies and resources to demonstrate the value of a career in transportation and provides career preparation to a new audience of people.

The Virtual Public Involvement initiative continues the efforts started in EDC-5 promoting transportation agency efforts to engage the public more effectively during the transportation decisionmaking process by supplementing face-to-face information sharing with technological tools and techniques.

Another initiative continuing from EDC-5, Crowdsourcing for Advancing Operations promotes using crowdsourced data integrated from multiple streams to optimize roadway use for reduced congestion and increased safety and reliability.

Innovative Materials Solutions

The EDC-6 lineup also includes two products with great potential to best use the available resources of transportation agencies. With many pavements in the highway system nearing or reaching the end of their design life, a toolkit of Targeted Overlay Pavement Solutions is now available for asphalt and concrete pavements that enable agencies to retain the value of existing pavements in need of treatment, maximize their investment, and help ensure safer, longer-lasting roadways.

Ultra-High Performance Concrete (UHPC) for Bridge Preservation and Repair presents a new application of UHPC—a fiber-reinforced, cementitious composite material with mechanical and durability properties that far exceed those of conventional concrete—that offers superior strength, enhanced performance, and improved life-cycle cost over traditional preservation and repair methods.

Thin overlays can be designed specifically to improve rutting and cracking resistance, increase structural capacity, improve friction, or reduce splash and spray.

© National Asphalt Pavement Association.

Improving Transportation Processes

Two EDC-6 initiatives seek to enhance transportation projects and programs by implementing effective processes.

Next-Generation Traffic Incident Management (NextGen TIM) programs aim to shorten the duration and impact of roadway incidents and improve the safety of motorists, crash victims, and responders. New tools such as unmanned aircraft systems, data analytics, and computer-aided dispatch systems help agencies better detect and manage traffic incidents.

The e-Ticketing and Digital As-Builts innovation helps agencies leverage and integrate the massive amounts of valuable data generated during highway construction projects into electronic and digital workflows. Electronic ticketing improves the tracking, exchange, and archiving of materials tickets. Digital as-built information enables agencies to capture various data elements, such as utilities and other subsurface features in the as-built plans to support future operations, maintenance, and asset management.

e-Ticketing uses mobile devices to access electronic ticket exchanges, improving material data handling and integration into construction management systems.

Source: FHWA.

Getting Round 6 Underway

In December 2020, FHWA hosted a virtual summit to enable the State Transportation Innovation Councils to explore the benefits of the EDC-6 innovations and identify those that best fit the needs of their transportation programs. All presentations are available on demand at *www.labroots.com/ms/virtual-event/fhwa-everyday-counts-6-virtual-summit*. In January, EDC-6 deployment teams began providing technical assistance and training to help transportation agencies implement the innovations at their chosen levels of adoption.

For more information, visit *www.fhwa.dot.gov/innovation/everydaycounts*.

JULIE ZIRLIN is the Every Day Counts Program Manager in FHWA's Center for Accelerating Innovation.

The New York State Department of Transportation frequently uses UHPC link slabs to replace deteriorated expansion joints.

© 2019, New York State Department of Transportation.

Reducing Rural Roadway Departures: Moving FoRRRwD, Part II

FHWA's Every Day Counts initiative is taking a comprehensive approach to saving lives on rural roads.

About one-third of the Nation's annual roadway deaths occur on rural roads. Implementing proven countermeasures and developing safety action plans can help local agencies address the problem.

© Franklin County, OH.

by **CATHY SATTERFIELD** and **RICHARD B. ALBIN**

Each year in the United States, nearly 12,000 people die when their car leaves its travel lane on a rural road. That is 30 people today, and every day.

The Federal Highway Administration is working with State departments of transportation, Local Technical Assistance Program centers, and local agencies across the country to combat this issue. Under the Every Day Counts initiative called Focus on Reducing Rural Roadway Departures (FoRRRwD), the team is promoting further use of proven strategies to reduce rural roadway departures. Many agencies are using these strategies and seeing positive results. The efforts of these agencies are getting more people home safely.

A Far-Reaching Problem Requires A Comprehensive Approach

The FoRRRwD approach is based on four pillars. The first article in this series (see "Moving FoRRRwD: Focus on Reducing Rural Roadway Departures" in the Autumn 2020 issue of *Public Roads*) focused on the scope of the problem and the first two pillars—all public roads and the implementation of a systemic safety approach. This article focuses on the other two pillars—the countermeasures recognized to reduce rural roadway departures and the development and implementation of safety action plans.

Proven Countermeasures

There are many cost-effective countermeasures shown to reduce rural roadway departures. When properly applied, they can significantly reduce serious and fatal crashes.

Although rural roads are extremely diverse, from multilane highways to gravel roads, there are countermeasures demonstrated to fit most situations. For example, edge line markings are effective at reducing roadway departures, but they cannot be installed on gravel or dirt roads. However, delineators can be used instead on these roads and accomplish a similar goal. Other treatments are more complex, but any agency can find some method to improve their roadways. If improving entire corridors is not practical, focusing on curves might be appropriate, since 42 percent of rural roadway departure fatalities occur at horizontal curves. The FHWA guide *Low-Cost Treatments for Horizontal Curve Safety 2016* (FHWA-SA-15-084) provides information on the application and benefits of many countermeasures.

The proven countermeasures are organized around three objectives for reducing rural roadway departure deaths and serious injury crashes. In priority order, these are: (1) Keep vehicles in their lane, (2) Reduce potential for crashes when vehicles leave their lane, and (3) Minimize severity if a crash occurs. There are specific countermeasures that apply to each objective (*https://safety.fhwa.dot.gov/FoRRRwD/countermeasures.cfm*).

Keep Vehicles in Their Lane

The primary objective is to prevent drivers from leaving their travel lane. Another term for roadway departure is lane departure, which also includes crossing the center line. Once a driver departs the lane onto the roadside or across the center line into oncoming traffic, the likelihood of a severe crash rises dramatically.

Signs and Markings

In general, pavement markings, signage, and other delineators are used to provide better visibility of the lane or roadway edges, particularly where the alignment changes. This delineation is critical in nighttime conditions where other cues are not available. Basic signing and use of center and edge lines are the first steps to providing more visible roadways. These countermeasures have been shown to be very effective. For instance, chevron signs on horizontal curves can reduce nighttime crashes by up to 25 percent.

Enhanced delineation may be useful where risk factors indicate it will improve driver perception. Potential countermeasures included in this strategy are wider center and edge line markings; post-mounted delineators; signs that are larger, more retroreflective, or fluorescent; and dynamic advance curve warning signs and sequentially flashing chevron signs.

Graphic retroreflective signs like these curve chevrons provide improved nighttime visibility.

Source: FHWA.

FHWA produced a short video about rumble strips. It is available on the agency's official YouTube channel at *www.youtube.com/watch?v=2V5-M4-O70E&feature=youtu.be*.

Source: FHWA.

Rumble Strips

Rumble strips are another very effective countermeasure for keeping vehicles in their lane. On two-lane rural roads, centerline rumble strips have been shown to reduce opposite direction fatal and injury crashes by 45 percent, and shoulder or edge rumble strips reduce single vehicle run-off-road fatal and injury crashes by 36 percent.

Alternative designs and applications have been developed to address issues related to bicycle accommodation and noise. Creating bicycle gaps and placing rumble strips on the edge line may better enable bicyclists to use the shoulder. Sinusoidal rumble strips, designed with an oscillating sine wave pattern to reduce noise outside of the vehicle, show promise to combat noise concerns (see "Did You Hear That?" in the January/February 2017 issue of *Public Roads*). Multiple States are trying these, so data should soon be available to assess if sinusoidal rumble strips provide the same level of crash reduction as conventional rumbles.

Many agencies have *systematic* criteria for installing center and edge rumble strips over a portion of the system. A *systemic* approach may be better, especially for agencies just beginning to consider rumble strips. (For more information on systematic vs. systemic approaches, see "Moving FoRRRwD: Focus on Reducing Rural Roadway Departures" in the Autumn 2020 issue of *Public Roads*). Installing them on corridors of highest risk for roadway departure fatal and injury crashes provides the opportunity to achieve the highest number of crash reductions for each dollar spent.

High-Friction Surface Treatments (HFST)

HFST greatly increases friction on roadway surfaces. This is particularly important in locations such as curves, where friction is critical and tends to deteriorate prematurely. HFST is a very durable treatment at such locations, and reduces the need to implement higher cost solutions, such as curve flattening, increased superelevation, or reconstruction. It may also eliminate the need for additional rights-of-way.

This countermeasure has been shown to reduce wet weather curve crashes by 83 percent and reduce overall curve-related crashes by 57 percent. It has also been shown to be highly cost-effective, with a benefit-cost ratio of 6:1. Like other countermeasures, project locations can be bundled to increase cost-effectiveness.

For example, the Kentucky Transportation Cabinet installed HFST in 15 short curves on the minor road system and achieved a more than 70-percent reduction in overall crashes. At several sites, there were zero crashes in the 5-years-after period.

HFST has been shown to reduce wet weather curve crashes by 83 percent.

Source: FHWA.

Reduce Potential for Crashes

While keeping vehicles on the roadway is the first priority, there are several proven strategies for reducing the likelihood of a crash for those vehicles that do leave the roadway.

SafetyEdge℠

The SafetyEdge technology shapes the edge of the pavement at approximately 30 degrees from the pavement cross slope during the paving process. That angle eliminates the potential for vertical dropoff at the edge of the pavement and enables drivers to recover and re-enter their lane with less potential to lose control. Because the SafetyEdge is installed during the paving process, there is minimal effect on asphalt paving cost, and it can improve pavement durability by preventing edge raveling. Evaluations of safety effectiveness have shown a 21-percent reduction in run-off-road crashes and a

Rumble strips are effective for keeping vehicles in their lanes. Widening shoulders provides space for vehicle recovery and can also provide room for rumble strips.

Source: FHWA.

19-percent reduction in head-on collisions. This results in a very high benefit-cost ratio. SafetyEdge can also be installed on concrete pavements when they are constructed, although the cost is more significant than on asphalt projects.

Enhanced Roadside Design

Improving roadside design, especially at curves, includes adding or widening shoulders, flattening slopes and improving ditch design, and providing and maintaining adequate clear zones.

Shoulder widening creates additional space for a vehicle to recover and can be done in conjunction with installing rumble strips and adding SafetyEdge. Slope flattening reduces the steepness of the roadside and provides more stability, decreasing the potential for rollover, and increasing the opportunity for drivers to recover.

Providing a wider roadside clear zone often means removing rigid objects such as trees and utility poles. This can be more expensive than other countermeasures, but focusing these improvements to the outside of specific, higher risk curves systemically prioritizes higher risk locations. Safety effectiveness evaluations show a 22-percent crash reduction by increasing the distance to trees by 3 feet (0.9 meters), and up to 71-percent reduction when increased by 15 feet (4.6 meters).

Minimize Severity if A Crash Occurs

Sometimes crashes happen despite the best efforts of agencies to keep drivers in their travel lane or provide for a safe recovery. Where signs or poles are needed or where roadsides cannot practically be improved, hardware exists to minimize the severity of crashes that may occur. Two proven strategies for minimizing severity are installing breakaway and energy-absorbing designs on posts and poles and installing roadside and median barriers.

While installing a barrier can lead to an increase in total crashes because of reported property damage, it is important to remember that the goal is to reduce *fatal and serious injury crashes*. A sideswipe crash into a barrier will damage the vehicle, but is much less prone to cause serious injury to the people in the vehicle than a collision with a tree or a rollover on a steep slope.

The entire goal of the FoRRRwD effort is to save the *people* behind the crash numbers.

Choose the Options That Work for You

Severe rural roadway departure crashes can be reduced or eliminated in high-risk locations. A quote attributed to President Theodore Roosevelt applies: "Do what you can, with what you have, where you are." Agencies should use the proven countermeasures that best fit their situations and budgets—but leaving them on the shelf should not be an option.

The three objectives of keeping vehicles in their lane, reducing potential for crashes, and minimizing crash severity can also be combined to provide redundancy. Providing curve signing to keep vehicles on the road will reduce crashes. However, combining them with the removal of fixed objects or providing a barrier will compound the reduction. This redundancy will be critical to achieve the vision of zero fatalities. "Think of the countermeasures as a menu of options," says Cornell Robertson, the county engineer for Franklin County, OH. "Each has a specific focus, but they can be used together for maximum effect."

Installation of multiple countermeasures or multiple project locations can also be bundled together in a single contract to increase cost-effectiveness. Bundling can happen within a single agency or across a region and involve several agencies. This provides an opportunity to get more done within a small budget.

Safety Action Plans

The first three FoRRRwD pillars—considering all public roads, using a systemic approach, and implementing proven countermeasures—provide the tools

Agencies can tailor their local road safety plans to meet their specific issues and needs.

Source: FHWA.

necessary to reduce roadway departures. Using them to develop an action plan is an effective way to prioritize and communicate an agency's safety needs.

Safety action plans, such as statewide roadway departure action plans or local road safety plans, provide a framework to identify, analyze, and prioritize roadway safety improvements. The process for developing these plans is flexible and can be easily tailored to specific agency issues and needs.

Safety action plans have many benefits. A plan enhances the awareness of stakeholders about the need to tackle rural roadway departure crashes. In developing the plan, agencies establish partnerships that can be further leveraged for implementation.

Plans can also be a communication tool to explain investment decisions to staff, leadership, and the public. By documenting data analysis, recommendations, and implementation strategies, the plan explains the project prioritization—why particular projects need to be done at certain locations and in what order. In addition, a plan may help an agency compete for additional funding in some instances and provides a yardstick to measure the agency's efforts.

"Our safety plan has been a catalyst to bring all our stakeholders together with one vision," says Craig Parks, the former county engineer for Boone County, IN. "We included law enforcement, public health, and elected officials. When we all looked at the plan together, they really understood that we were making data-driven decisions, and all of us had a part to play in getting people home safely each day."

Another benefit of having an action plan is that it can survive staff turnover. As people move in and out of an agency, the plan provides a consistent path to guide those who were not there when it was developed.

Plans are also scalable, and can be customized to an agency's needs and priorities. They are not one size fits all. Some agencies' plans are just a few pages. Others comprise more than 100 pages. The plan depends on what the agency's individual needs are and what it is trying to accomplish.

Implementation Is Required

Safety action plans are proven to work if they are implemented. It is critical that agencies commit to seeing the improvements identified in their plans become a reality—the reason someone makes it home safely today. To get the most out of a safety action plan, agencies should consider aligning the plan with existing priorities, engaging maintenance staff, including implementation strategies, and marketing.

Align the plan with existing priorities. Every State has a strategic highway safety plan (SHSP) that outlines safety issues to be addressed statewide. As much as possible, match safety projects in the safety action

plan with SHSP priorities. This can build support for the plan. However, these priorities may need to be adjusted based on an agency's own data.

Engage maintenance staff. Many times, operations and maintenance staff form the front line of local agencies. Include maintenance staff in the development of local road safety plans. They can then be proactive in installing low-cost countermeasures identified from the plan during their routine work.

Include implementation strategies. Along with the locations where countermeasures will be effective, include strategies to cost-effectively implement them in the plan. Strategies might include maintenance staff performing the work, bundling projects with similar treatments into a single contract, or installing countermeasures during other planned work in those corridors.

Market the plan. Be intentional with marketing and outreach. Marketing safety is especially important when developing a local road safety plan. Know the stakeholders and target the message to the specific audience. Add it to the agenda in formal meetings, but also bring it up in conversation. Talk about the benefits consistently to bring as many people as possible into the process, across diverse functional areas and even other agencies. Consistent marketing builds buy-in.

Help Is Available

Through the FoRRRwD effort, agencies looking to develop or implement safety action plans can request technical assistance on any aspect of plan development. Examples of technical assistance provided include:

- Helping to form a stakeholder group.
- Conducting data analysis for agencies.
- Providing or customizing tools for agencies to analyze their own data.
- Identifying potential countermeasures based on risk factors, target crash types, and target facility types from the analysis.
- Developing timelines and goals for implementation.
- Evaluating the effectiveness of countermeasures already installed.

FHWA has launched a new Local Road Safety Plan Do-it-Yourself website at *https://safety.fhwa.dot.gov/LRSPDIY* to help local agencies. The site includes video content to explain and demonstrate the steps of the planning process and offers dozens of tips, tutorials, resources, and examples. The site houses previously developed infographics, templates, videos, presentations, webinars, training modules, and tools, as well as featured interviews with State and local agencies that have been engaged in developing local road safety plans across the country. For more information, see "Internet Watch" on page 45 in this issue.

Save the People Behind The Numbers

"Rural roadway departure crashes represent a huge challenge on the Nation's roadways," says Michael Griffith, director of FHWA's Office of Safety Technologies. "There is, however, a clear path to reducing them and help is available from FHWA."

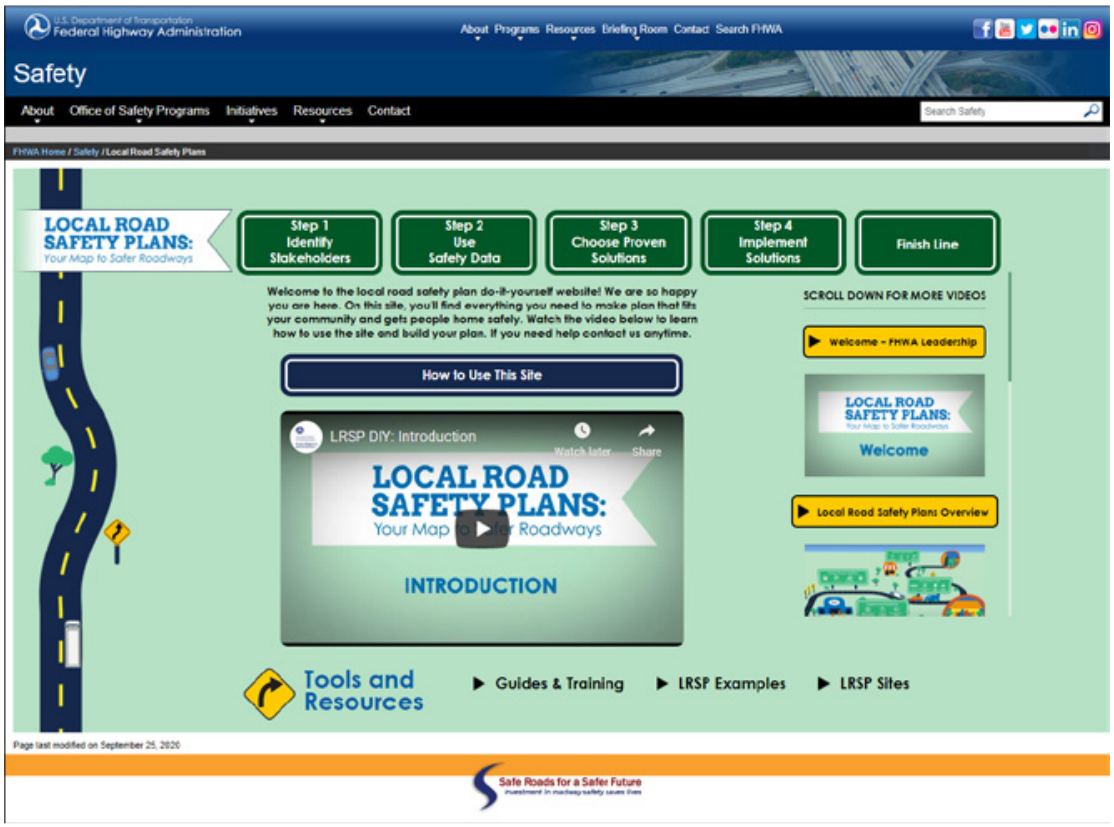
FHWA urges States to consider all public roads, use a systemic approach, implement proven countermeasures, and develop a safety action plan. These four pillars are proven to work.

Thirty people will die today from rural roadway departure crashes. Some of them could be your neighbors or loved ones. Let's save the *people* behind the numbers!

CATHY SATTERFIELD, P.E., works on roadway departure and visibility programs in FHWA's Office of Safety. She has a B.S.C.E from the University of Minnesota.

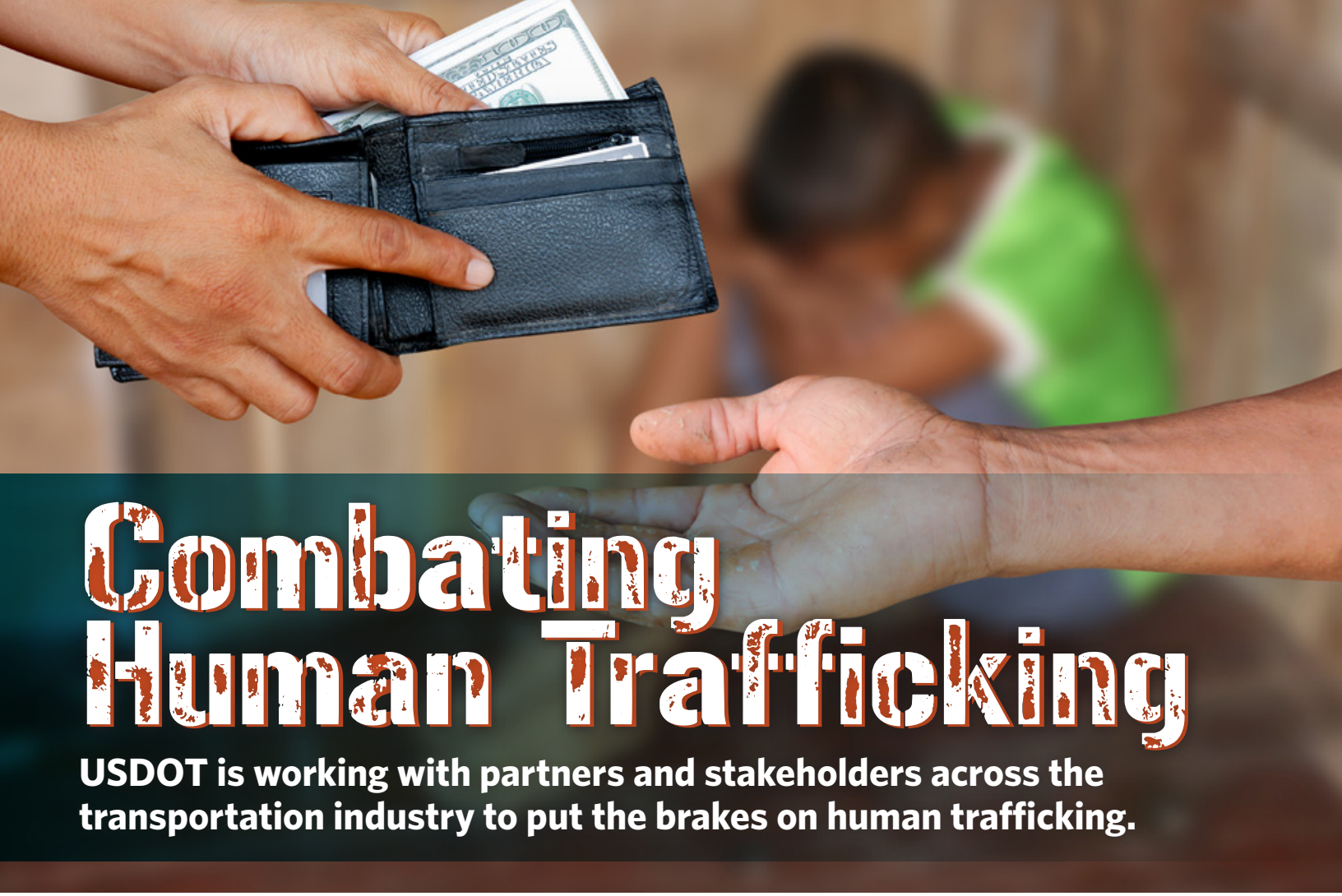
RICHARD B. ALBIN, P.E., is with the FHWA Resource Center and specializes in reducing roadway departure crashes. He has a B.S.C.E. from the University of Wyoming.

For more information, see *www.safety.fhwa.dot.gov/forrrwd* or contact Cathy Satterfield, *cathy.satterfield@dot.gov*, or Dick Albin, *dick.albin@dot.gov*.



FHWA's new website helps agencies develop a local road safety plan.

Source: FHWA.



Combating Human Trafficking

USDOT is working with partners and stakeholders across the transportation industry to put the brakes on human trafficking.

The transportation sector can do a lot to help stop human trafficking.

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by **JIHAN NOIZET** and **SHARI SCHAFTLEIN**

Human trafficking is a form of modern-day slavery that involves the use of force, fraud, or coercion to obtain labor or a commercial sex act and includes the commercial sexual exploitation of children under any circumstances. The International Labour Organization estimates that, globally, as many as 24.9 million men, women, and children are exploited in various forms of contemporary slave-like practices. Human trafficking flourishes as a business because of the lucrative profits it generates—approximately $150 billion annually worldwide.

Traffickers rely on the transportation industry in every phase of human trafficking: for recruitment, for moving and controlling victims, and for delivering victims to buyers. In the United States, victims are being trafficked by every form of transportation, including cars, vans, buses, airplanes, subways, trains, taxis, rideshares, and cruise ships.

"The U.S. Department of Transportation is committed to working with our public and private partners to fight human trafficking on America's transportation system," said U.S. Secretary of Transportation Elaine L. Chao.

In 2018, USDOT launched its Advisory Committee on Human Trafficking (ACHT). ACHT is a Federal advisory committee created in accordance with the Combating Human Trafficking in Commercial Vehicles Act to make recommendations to the Secretary of Transportation on actions the Department can take to help combat human trafficking, and to develop recommended best practices for States and local transportation stakeholders in combating human trafficking. The Secretary appointed the 15 members as a cross-section of stakeholders from industry and labor, including representatives from the aviation, bus, law enforcement, maritime, port, rail, and trucking sectors.

In July 2019, the committee published its final report with recommendations, which is available at *www.transportation.gov/administrations/office-policy/advisory-committee-human-trafficking*. The report provides valuable feedback that methodically assesses data, strategies, policies, protocols, and public awareness at the intersection of the transportation sector and human trafficking.

USDOT's Counter-trafficking Efforts

Since the ACHT issued its final report, including recommendations for the Department, USDOT has both continued and expanded counter-trafficking leadership, partnerships, funding, training, awareness, and research efforts. The Federal Highway Administration is working on initiatives to engage stakeholders and promote public awareness.

Partnerships

USDOT significantly expanded its Transportation Leaders Against Human Trafficking (TLAHT) partnership, with pledges signed by stakeholders from every mode of transportation, labor, and nongovernmental organizations from every State in the country. Signatories commit to educating employees, raising public awareness, and sharing data on the issue of human trafficking. More than 500 transportation

Secretary of Transportation Elaine L. Chao (center) with USDOT's Advisory Committee on Human Trafficking (ACHT) in 2019.
Source: USDOT.

stakeholders have signed the pledge. As of October 2020, signatories include 184 airports and airlines, 136 urban and rural transit agencies, 35 trucking and bus companies, 9 railways, 7 ports, 49 State departments of transportation, 8 States, and 11 cities.

Funding

USDOT awarded more than $1.5 million in grants to support State counter-trafficking efforts through driver's license standards and programs, $5.4 million in transit grants to address public safety (including human trafficking), and $50,000 to the winner of the new annual Combating Human Trafficking in Transportation Impact Award.

Training

In addition to continuing to train its 54,000 employees every 3 years, USDOT's Blue Lightning Initiative training—tailored for the aviation sector and a joint effort with the Department of Homeland Security—expanded to 49 partners that include airlines, airports, and aviation associations reaching more than 100,000 aviation employees. Many of USDOT's human trafficking-related grants include support for expanded training initiatives, and TLAHT partners have committed to training 1.3 million transportation employees to recognize and respond to possible instances of human trafficking.

Awareness

USDOT delivers presentations, convenes stakeholders, displays exhibits, and posts messages on social media to raise awareness about the intersection of human trafficking and transportation. Many of the Department's grants that include a human trafficking component support expanded public awareness on the issue, and the TLAHT pledge also encourages stakeholders to raise public awareness. The Department provides outreach resources to stakeholders at *www.transportation.gov/stophumantrafficking*.

Research

During the 2020 Transportation Research Board 99th Annual Meeting of more than 14,000 transportation researchers and professionals, one of USDOT's keynote presentations and an exhibit underscored the role of transportation in combating human trafficking and highlighted key research gaps and opportunities. USDOT continues to support TRB's research programs on the intersection of human trafficking and transportation. The Department presented its inaugural Combating Human Trafficking in Transportation Impact Award to United Against Slavery to conduct a national counter-trafficking survey of transportation stakeholders of up to 500,000 respondents, the results of which will be available to the public, helping to inform future research on the intersection of human trafficking and transportation.

Going Beyond Required Training

Practitioners in the highway sector of transportation use multimodal options in their professional and personal travel, so it is helpful for them to have an understanding of how other modes are involved in human trafficking. Participating in training beyond what is required can help transportation

In January 2020, leaders from Congress, State governments, and the transportation industry joined Secretary Chao (center) to pledge their commitment to fight human trafficking.
Source: USDOT.

Recommended Trainings

Target Transportation Sector	Training Name	Link	Notes
Aviation	Blue Lightning Initiative	*https://www.cbp.gov/border-security/human-trafficking/blue-lightning*	3-minute preview of the training. Full access requires a Memorandum of Understanding with USDOT and the Department of Homeland Security.
Rail (Amtrak)	Hiding in Plain Sight	*https://www.youtube.com/watch?v=JXIFBFyZbPs*	12-minute video
State Agencies: Pennsylvania DOT Training	Combating Human Trafficking	*http://www.dot13.pa.gov/Combating%20Human%20Trafficking%20WBT/story_flash.html*	11-minute interactive video

professionals increase their knowledge and awareness to serve as champions against human trafficking. There is a wide variety of transportation training available online that transportation professionals can take on a voluntary basis to supplement required training. In particular, there is the Blue Lightning Initiative for aviation; "Hiding in Plain Sight," intended for Amtrak and the rail sector; and the Pennsylvania Department of Transportation's "Combating Human Trafficking" training.

The Role of State DOTs

Efforts among State DOTs to stop human trafficking are picking up momentum, although there is still a ways to go. State DOTs have access to pertinent information that can be useful to law enforcement in the quest to combat human trafficking. Given the role of State DOTs in building, maintaining, and regulating multiple large-scale transportation systems, State DOTs can be well positioned to make an impact in combating human trafficking. One of the most powerful resources available to State DOTs is their human capital. When employees are educated and trained on preventing human trafficking, they function as not only frontline deterrents but also as multipliers by helping to spread awareness to the public.

The ACHT report offers a substantial number of recommendations for the States. Three critical ones are training, awareness, and partnerships.

"Training is instrumental in ensuring frontline employees are prepared to respond to potential trafficking situations," says Yassmin Gramian, Secretary of Transportation at the Pennsylvania Department of Transportation. "Making sure that everyone is on the same page can save lives."

States have found success with general human trafficking awareness training of State transportation employees and law enforcement officials that includes case studies and scenario-based trainings. This approach has the ability to engage stakeholders and keep them vested in the process.

Additionally, it is important to raise public awareness and adopt a uniform message among stakeholders through the use of targeted materials. Adopting a uniform message using existing materials from Federal agencies emphasizes the message and provides an unvarying communication effort across all stakeholders involved—presenting a combined front against human trafficking as a whole.

Finally, partnerships are crucial to the success of getting key messages out to stakeholders. Creating a comprehensive approach to human trafficking through coalitions emphasizes that this issue transcends all communities, States, and the Federal Government. The American Association of State Highway and Transportation Officials is providing a forum at national and regional meetings for leadership peer exchange on the subject.

Transportation Research Board Initiatives

USDOT has partnered with TRB to accomplish several coordination and outreach efforts. These include a session at the 6th International Conference on Women and Transportation Issues, held in Irvine, CA, in September 2019, as well as 2020 TRB Annual Meeting events. In July 2020, TRB sponsored a webinar on Human Trafficking and Mobility of Missing and Murdered Indigenous Women. TRB has also recently formed the Human Trafficking in Transportation Common Interest Group Steering Committee. The objectives of the group include

Awareness, research, training, and collaboration are all important in the battle against human trafficking.

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USDOT is collaborating with partners in the United States and abroad to put the brakes on human trafficking.

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knowledge sharing, collaboration, and serving as champions on the anti-human trafficking topic.

In addition, human trafficking projects are included in two research programs that TRB administers: the National Cooperative Highway Research Program (NCHRP) and the Airport Cooperative Research Program (ACRP).

TRB's NCHRP Research Efforts

The NCHRP is spearheading research to inform State DOTs interested in developing structured responses to human trafficking that are appropriate to their State, in addition to supporting employees who may be on the front lines against this criminal activity. The objectives of NCHRP project 20-121, State DOT Contributions to the Study, Investigation, and Interdiction of Human Trafficking, are to identify how State DOTs can assist and enhance the existing efforts to combat human trafficking, and to develop guidelines and a suite of tools that support effective training, policy, and collaborative practices related to mitigating human trafficking.

The first phase of this research is complete, and the results will be published in early 2021. Using the ACHT framework, the report will summarize findings and conclusions, and provide definitions, sample policies, scenarios, and program management tools.

The State DOTs, through AASHTO, recently added additional funding to the project. A second phase will support dissemination and implementation of the research results, with a focus on prevention, protection, prosecution, and partnerships.

Some insights from the project to date include that partnering is key and that law enforcement and victim services are instrumental to fighting human trafficking. It is also essential to address common State DOT programming needs. These include executive-level interest and internal capacity within the State DOT; clear objectives aligned to partner expectations; program governance that is explicit and well-communicated to the rest of the organization; training, policies, and processes (for example, making reporting familiar and automatic); education of external partners on what State DOTs bring to a broader anti-trafficking effort; and the need for a connected community of interest with recurring contact.

"Human trafficking is an issue that all States and communities have a role in combating, and this report is a critical step in arming State DOTs with information to increase awareness and further advance anti-trafficking measures," says Arlin Alvarez, the Wellness Program administrator for the Texas Department of Transportation (TxDOT) and co-chair of the NCHRP's project panel for State DOT Contributions to the Study, Investigation, and Interdiction of Human Trafficking. "As TxDOT continues to amplify and expand the human trafficking awareness campaign we launched in 2019, we appreciate every opportunity to collaborate with our fellow DOTs to share resources and insight on how we can collectively make a positive difference by watching for and reporting trafficking."

TRB's ACRP Research Efforts

The ACRP has launched ACRP project 04-24, Guidelines to Develop an Anti-Human Trafficking Action Plan for Airports, to develop a primer, guidebook, and toolkit to help airport operators create and implement a comprehensive anti-human trafficking action plan.

How State DOTs Can Help Law Enforcement

State DOTs can support law enforcement by supplying certain knowledge, data, and expertise. Providing these resources may produce actionable information or corroborating evidence. Sources of information include:

- Surveillance information from rest areas and welcome areas.
- Documentation of observations by workforce in unpatrolled areas (for example, remote sites).
- Common trafficker routes or circuits—national, regional, and local.
- Information on suspected trafficker sites at or near transportation agency assets.
- Surveillance information from weigh stations, toll facilities, and similar roadside operations.
- Data on human trafficking activity from partner facilities.
- License plate images.
- Case studies from the transportation sector and State DOTs.
- Toll or station activity.
- Geospatial expertise (such as providing interpretation of aerial imagery).

International Outreach

USDOT uses its participation in international activities such as the Asia-Pacific Economic Cooperation (APEC) Transportation Working Group, the International Civil Aviation Organization, and the International Transport Forum to encourage counterparts across the globe to engage their stakeholders on the issue of combating human trafficking.

Within the APEC working group, USDOT is spearheading a project entitled "Combating Human Trafficking by Addressing Illicit Uses of Transportation." Under the project, two webinars were held in September and October 2020 on "Combating Human Trafficking in the Transportation Sector" and "Modal Strategies to Combat Human Trafficking." The two meetings focused on overarching best practices for transportation ministries, transport operators, law enforcement, and civil society organizations to combat human trafficking in the transportation sector through leadership, data collection, reporting, employee training, and public awareness.

One common thread among the webinars' presentations was the importance of partnerships within and between governments; with hotlines, where applicable; and with law enforcement. USDOT presented during both meetings and included examples of modal strategies in the trucking, transit, aviation, and port sectors.

Additional international cooperation efforts are needed to compile the state of practice and aspirational efforts focused on the highway system, including highways, arterials, adjacent supporting services, and land use, such as fueling, rest areas, and formal and informal right-of-way encampments. Highway transportation agencies collectively can consider how they can communicate with vulnerable populations, disrupt trafficking networks, and eliminate forced labor in transportation construction through effective design, licensing, contracting, and operation.

Combating Human Trafficking Together

FHWA strongly encourages its partners and stakeholders to sign the Transportation Leaders Against Human Trafficking pledge. USDOT's TLAHT group urges transportation leaders, including travel industry stakeholders, to connect in an effort to combat human trafficking. This initiative is supported by USDOT leadership across all levels and modal agencies. The Transportation Leaders Against Human Trafficking pledge is available at *www.transportation.gov/sites/dot.gov/files/2020-02/TLAHT%20Pledge%202020.pdf*.

"This call to action is not just at an organizational level, it is at a personal level, too," says Thomas Everett, FHWA's Executive Director. "We can all make a difference, as long as we do our part and educate ourselves—knowledge is power, knowledge saves lives."

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SHARI SCHAFTLEIN is the director of FHWA's Office of Human Environment. She has 33 years of public service spanning Tribal, State, and Federal governments and nonprofits. She has held leadership positions in the FHWA Office of Planning, Environment, and Realty for the past 16 years. She holds a bachelor's degree in public affairs and a master's degree in environmental science from Indiana University.

For more information, visit *www.transportation.gov/stophumantrafficking*, see "Internet Watch: Combating Human Trafficking" in the Autumn 2020 issue of *Public Roads*, or contact Jihan Noizet at *Jihan.Noizet@dot.gov*.

Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities

FHWA's ATTRI program is funding PedPal, a mobile app that enables pedestrians to communicate directly with signalized intersections and actively influence traffic control decisions to enhance their safety.

Pedestrians with vision or mobility impairments face challenges when crossing intersections. FHWA's Accessible Transportation Technologies Research Initiative is funding the development of the PedPal app to help.

© M. Bernardine Dias, Diyunu Consulting LLC.

by **GOVINDARAJAN VADAKPAT, STEPHEN F. SMITH, ZACHARY B. RUBINSTEIN,** and **M. BERNARDINE DIAS**

Transportation and mobility are key to quality of life, equity of opportunity, and economic well-being in urban environments. Yet for travelers with disabilities, navigation along city streets and access to public transportation present significant challenges and often impose severe limits on freedom of movement and the ability to accomplish normal daily activities. To explore the role of technology in addressing these challenges, the Federal Highway Administration established the Accessible Transportation Technologies Research Initiative (ATTRI).

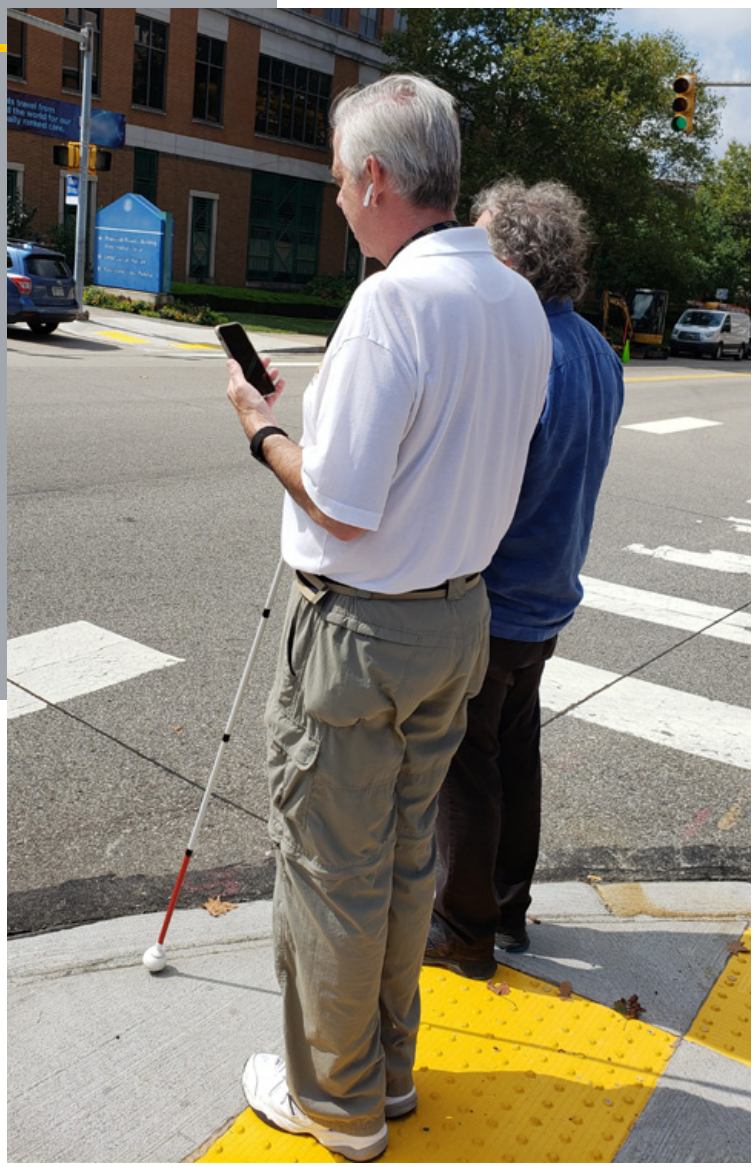
One focus of the ATTRI program is the problem of safe intersection crossing. "For a pedestrian who is vision impaired, navigating intersections poses a particularly daunting task," says Mohammed Yousuf, the director of the Federal Transit Administration's Office of Infrastructure and Innovation, and formerly the program manager for ATTRI at FHWA.

Most frequently, the pedestrian must rely on the directional sounds of traffic to first orient him or herself to the intended crossing direction and then to determine when it is time to cross. These decisions can be facilitated in situations where other pedestrians are present or if the intersection is equipped with accessible pedestrian signals, which provide audible and vibrotactile cues. In the absence of such cues when crossing unfamiliar intersections, a common strategy for a pedestrian who has a vision impairment is to remain at the intersection for one or more cycles of the traffic signal phases in order to acclimate and understand traffic patterns sufficiently before making a move to cross. Once a decision is made to cross, the pedestrian generally moves as quickly as possible, using cues such as the crown of the road at the middle of the crossing to gauge progress. Despite his or her best efforts, the safety of a pedestrian with a vision impairment often depends on the alertness and accommodation of the drivers of oncoming vehicles.

For pedestrians who have a mobility impairment, the basic challenge is getting across the intersection in the time that is allocated by the traffic signal control system, and, again, safety often depends on the patience of the drivers of waiting vehicles as the traffic signal changes phases.

"For pedestrians with a combination of disabilities," says Yousuf, "the situation is even worse."

To help address these challenges, Carnegie



A pedestrian who has a vision impairment waits at an intersection for the PedPal app on his smartphone to announce that it the light has changed and it is time to cross.

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Mellon University, with funding from ATTRI, developed PedPal, a mobile smartphone application that enables pedestrians to communicate directly with signalized intersections and to influence traffic control decisions to their advantage. PedPal combines emerging connected vehicle communication technology with a recently developed real-time, adaptive traffic signal control system to provide for a safer and more efficient intersection crossing experience for pedestrians with disabilities.

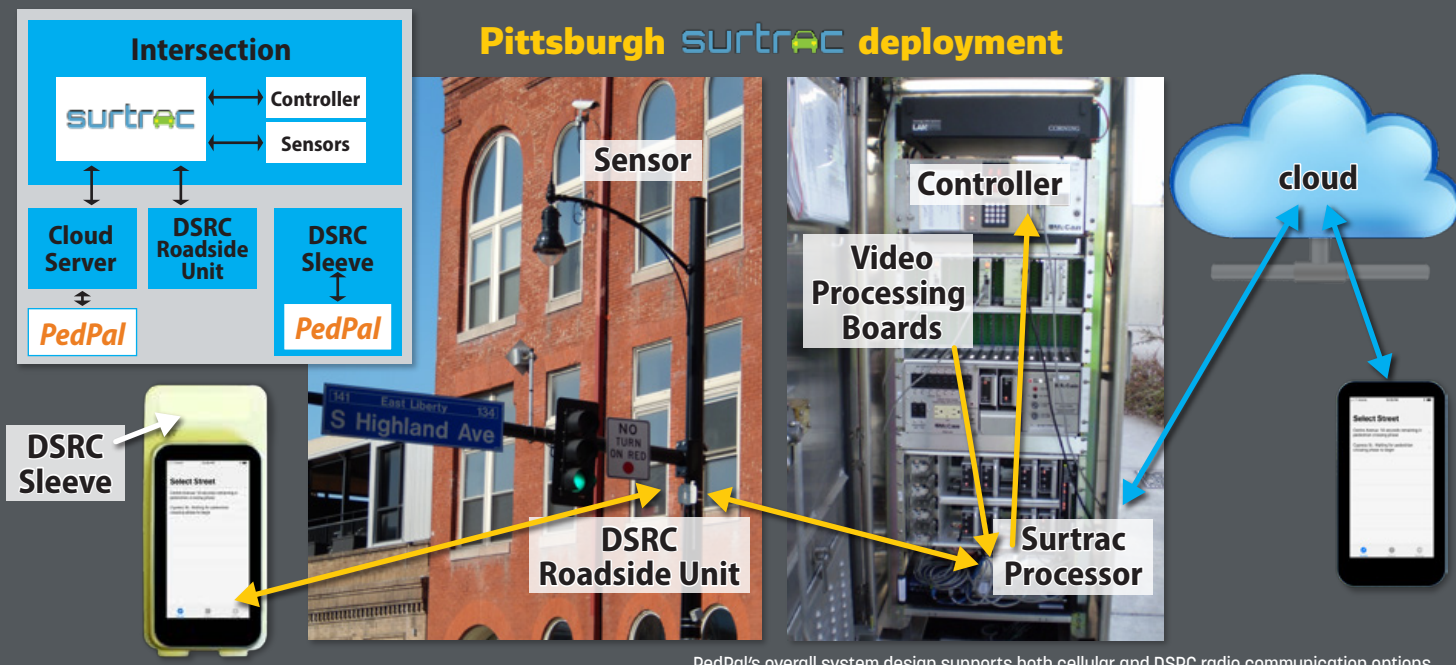
How PedPal Works

PedPal encodes its user's personal crossing constraints (such as travel speed) and conveys both desired crossing direction and required crossing time to the traffic signal system upon arrival at the intersection. The signal system, which is optimizing movement of all sensed traffic in real time, will in return ensure that the pedestrian gets the requested crossing duration whenever it initiates the next crossing phase in the pedestrian's direction. During crossing, PedPal and the traffic signal system communicate while PedPal monitors its user's progress, and, if progress is determined to be slower than expected, then the signal phase is dynamically extended by the signal system to accommodate this longer passage requirement.

If the user provides PedPal with pre-planned route information, the traffic signal control system can anticipate the pedestrian's arrival time at the intersection. By factoring this information into its determination of the upcoming signal timing plan, the system will coordinate a more efficient crossing opportunity that streamlines the user's overall crossing time.

System Design

To realize the functional behavior, PedPal takes advantage of recent technology advances in two areas: (1) vehicle-to-infrastructure (V2I) communication, which has produced both hardware devices such as dedicated short-range communication (DSRC) radios and



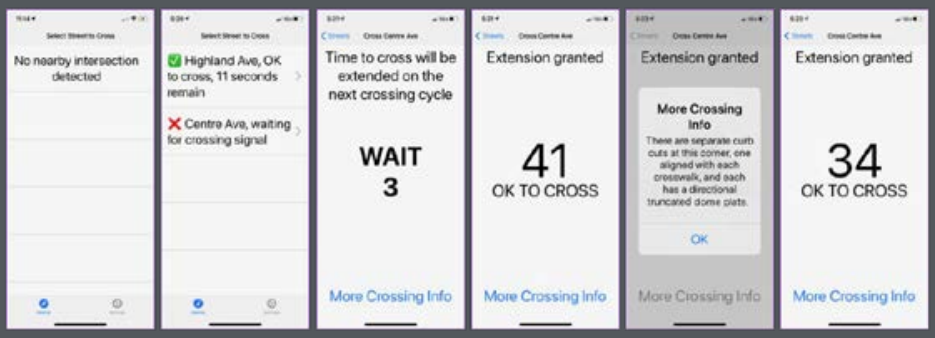
PedPal's overall system design supports both cellular and DSRC radio communication options.

© Stephen F. Smith, Carnegie Mellon University.

These screenshots (at right) demonstrate the basic PedPal concept of operations.

Crossing an Intersection with PedPal

Once a pedestrian launches PedPal, the app begins "listening" for specific messages broadcast from nearby smart signalized traffic intersections, and it continues to be active until explicitly turned off. While active, the app continues to cycle through the screens shown here.



Screen (a): The "No nearby intersection detected" message indicates that the device is currently between intersections and offline.

Screen (b): When within range of the messages being broadcasted by an upcoming intersection, the app uses this information to display possible crossing options to the user, along with context about when the crossing direction is going to change. Upon arrival at the intersection, the user indicates crossing intent by tapping on one of the presented options, which can be displayed visually or via audio voiceover.

Screen (c): When the pedestrian makes a selection, PedPal automatically sends a message to the intersection indicating both the crossing option selected and the time required, and the app display transitions to a screen that provides guidance relevant to the selected crossing phase. If the user has selected a future crossing phase, PedPal warns the user that it is not safe to cross. If voiceover has been enabled, this message is conveyed through audio as well as visually. When the crossing signal is close to changing to the desired crossing direction, PedPal starts to count down the seconds to alert the user to get ready to go.

Screen (d): When the intersection's crossing signal switches to the user's direction, the app announces that it is OK to cross. At this point, the app shows the amount of crossing time that has been allocated and begins a countdown of the time remaining until the next signal change. Once the pedestrian starts to cross, the app begins to track crossing progress.

Screen (e): While in either waiting or crossing mode, the user can request available information to assist in orienting to the crosswalk at the current corner.

Screen (f): The countdown timer continues when the popup for more information is dismissed.

V2I messaging standards, and (2) real-time adaptive signal control, which provides the ability to install personalized crossing constraints to dynamically extend the crossing time when necessary and to proactively factor pedestrian arrival times into the intersection's signal timing plan.

PedPal is currently running on an iPhone, selected primarily for the accessibility features that it provides. With respect to V2I communication, the app provides both DSRC and cellular options, the former achieved via Bluetooth® communication between the smartphone and an attachable DSRC "sleeve," and the latter through a cloud-based server connection to the intersection. In both modes, standardized DSRC map data and signal phase and timing message types are used respectively to communicate relevant geometric information about the intersection (such as the number of lanes, lane width, etc.) and current phase information from the intersection (such as how much green time is left in the current crossing phase) to the PedPal app. Likewise, standardized signal request messages and signal status messages are used by PedPal to communicate crossing intent and requirements to the intersection. The PedPal app can be used at any signalized intersection that is adaptively controlled, and can compensate for the absence of pedestrian signals at the intersection.

For real-time adaptive signal control, PedPal currently relies on the recently developed Surtrac system, which was initially piloted and deployed in areas of Pittsburgh, PA, and is now operational in about a dozen North American cities. Surtrac is designed specifically for optimization of urban traffic networks, where there are multiple competing dominant traffic flows that change throughout the day. Surtrac takes a totally decentralized approach to traffic control. Each intersection allocates its green time independently in real time, based on actual incoming vehicle flows, as seen through video or radar detection devices. Then, once an intersection system has generated its timing plan, it communicates projected outflows to neighboring intersections to increase their visibility of future incoming traffic.

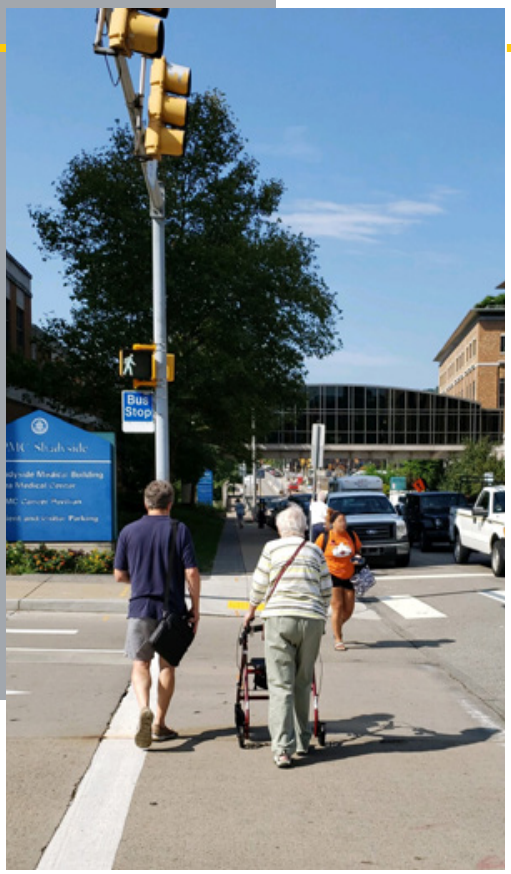
Timing plans at each intersection are executed in "rolling horizon" fashion, and the planning cycle repeats every second. Reliance on decentralized intersection control ensures maximum real-time responsiveness to actual traffic conditions, while communication of projected outflows to downstream neighbors enables coordinated activity at the network level and creation of green waves when appropriate. The real-time intersection scheduling procedure is sensitive to travel mode information (such as passenger vehicle, bus, bicycle, pedestrian) and capable of multimodal optimization if sensors (and in this case the PedPal app) can provide mode information.

The PedPal Mobile App

The PedPal app is the interface between the pedestrian and the traffic signal control system. The developers designed it to promote ease of use and follow universal design principles while taking full advantage of iPhone accessibility features to provide support for pedestrians with different types of disabilities. The interface emphasizes selection from tabs and lists of options rather than requiring textual inputs, and it provides multiple modalities to the user for presenting information and options for selection.

For pedestrians who are not vision impaired, the app's visual interface provides a straightforward basis for using the mobile app. Upon bringing up the app, the user has a choice of selecting one of two screens: "nearby," which provides the user with information and crossing options for the upcoming intersection, and "settings," which enables the user to customize the app's behavior for specific constraints and preferences. During travel and intersection crossing, the user will typically operate solely from the "nearby" screen.

Users who have vision impairments can



Volunteers from the local disability community in Pittsburgh tested PedPal in the field.

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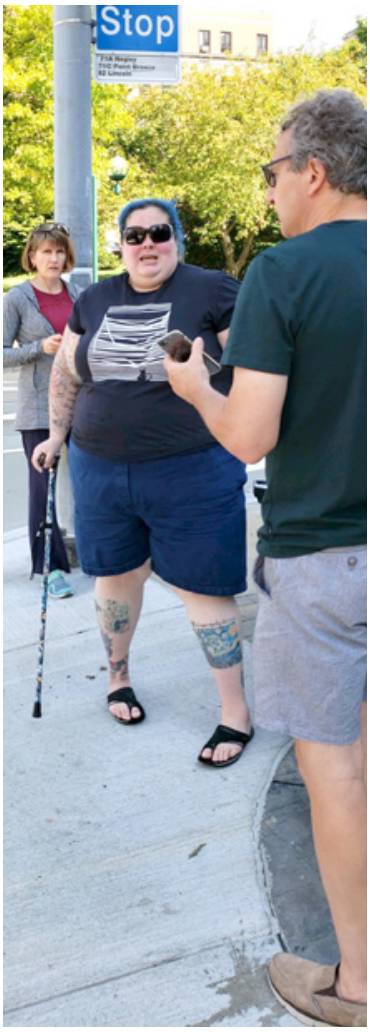

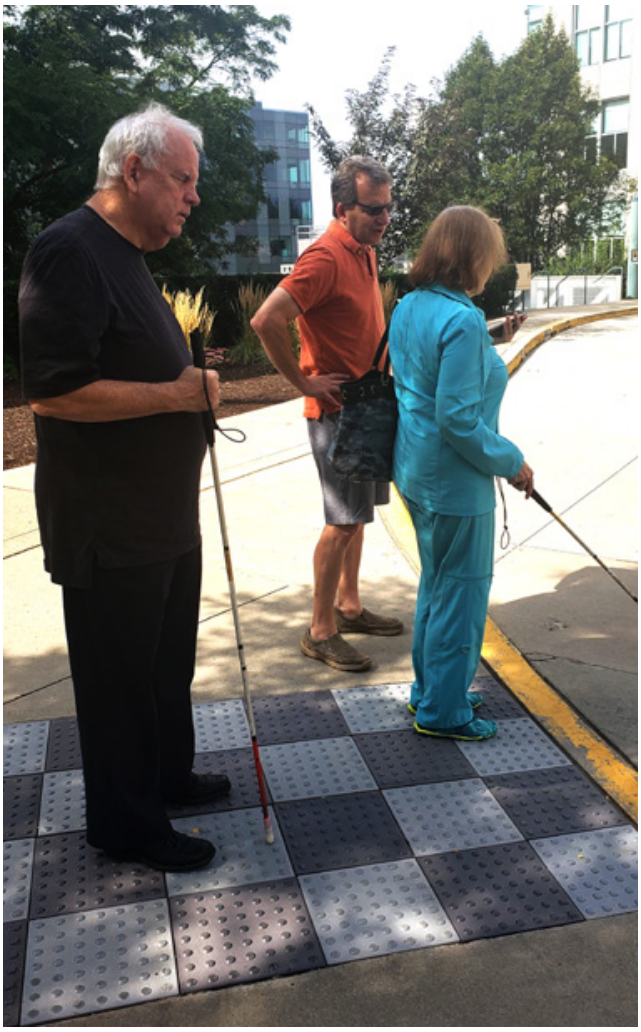

enable the smartphone's native accessibility features—including voiceover, font resizing, and text zooming—and configure them to facilitate interaction. The current PedPal prototype is implemented for the iPhone (in large part because of the relative strength of its onboard accessibility features), but the developers anticipate Android implementation in the future. Finally, the PedPal app is also designed to exploit haptic (vibration-based) cues for announcing walk/don't walk crossing conditions and for issuing alerts during the act of crossing.

Field Experiments

Carnegie Mellon carried out initial field testing of the PedPal mobile app at multiple intersections in the existing Pittsburgh Surtrac deployment to assess the app's potential and to obtain feedback for additional development. The development team recruited 14 people from the local Pittsburgh disability community, spanning a range of demographics and disability types but including a disproportionate number of individuals who have vision impairments. The team first interviewed each participant to form an understanding of his or her current challenges when crossing traffic intersections. Then each participant was trained in the use of the PedPal app and asked to perform a number of crossing trials both with and without the assistance of the app.

The developers used the crossings without the app as a control study for comparison with each user's crossing performance when using the app. The team recorded several measurements for each crossing trial, including the amount of time the user waited upon arrival at the corner, the number of traffic signal cycles that the user waited through while preparing to cross, and the eventual crossing duration. After the trials, participants were asked to complete a survey designed to get their qualitative assessment of the technology and suggestions for improvement.

Overwhelmingly, the feedback from participants was positive. Although it was clear that the app was perceived to be of more benefit to individuals with specific types of disabilities (such as walker users and pedestrians with vision impairments), all participants were enthusiastic

A guide dog user crosses a busy intersection with the help of PedPal.

© M. Bernardine Dias, Diyunu Consulting LLC.

about PedPal's potential to increase safety and enhance mobility for pedestrians with disabilities. One participant observed, "I rely on my Seeing Eye® dog to safely guide me across ... street crossings, and my Seeing Eye dog relies on me to confidently give the command to initiate a crossing. The PedPal app gives me the information I need to make an intelligent decision at a crossing, eliminating the need to interpret the cacophony of vehicular cues, often the lack of vehicular cues, and the occasional misinformation from fellow pedestrians."

Dr. Tessa McCarthy, an orientation and mobility specialist at the University of Pittsburgh, was also enthusiastic. "The PedPal app is one of the most innovative tools for street crossings that I've seen in my career," she says. "It has the ability to solve a lot of problems related to street crossings for people with a variety of disabilities."

Quantitatively, the research team found that the use of PedPal reduced both the total wait time and the number of cycles needed to cross for participants who have vision impairments. However, these participants actually moved across the intersection at a slower, relaxed pace when using PedPal. Based on observations and post-trial discussions with participants, this change in pace appears to correlate to the confidence users feel when crossing the street with the app: they feel more reassured that they are crossing at the correct phase and are less frantic in their movements as a result.

The observed results also confirmed prior expectations about the time required for crossing by different demographic groups. Individuals with mobility challenges who are walking require the most crossing time. Individuals who have vision impairments also require extra crossing time during periods of high traffic congestion. Alternatively, motorized wheelchair users and people with hearing loss cross intersections efficiently and do not need extra crossing time.

Next Steps

While a technological solution such as the PedPal app may not be right for every pedestrian, it can help many people with disabilities. Carnegie Mellon is currently expanding the PedPal technology to provide additional safety and mobility-enhancing capabilities, including the ability to detect veering outside of the crosswalk, to provide real-time feedback in an accessible format to pedestrians who have vision impairments, to import and export route information from third-party navigation apps, and to broadcast the presence of pedestrians with disabilities at the intersection to approaching connected vehicles. Carnegie Mellon is working with the company responsible for commercializing the Surtrac traffic signal control system to make the PedPal app available to any local municipality that has deployed Surtrac in the near future.

"The PedPal project has taken an important step toward realization of ATTRI's vision of an accessible transportation network that provides safe, easy, and efficient traveling options to everyone, especially to people with disabilities," says Yousuf.

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ZACHARY B. RUBINSTEIN is a principal project scientist at Carnegie Mellon University and project manager of the PedPal project. He holds a Ph.D. in computer science from the University of Massachusetts at Amherst.

M. BERNARDINE DIAS is a recognized world leader in the application of technology for social equity, and consulted on the PedPal project. She holds a Ph.D. in robotics from Carnegie Mellon University.

For more information, visit *https://rosap.ntl.bts.gov/view/dot/50548* or contact Govindarajan Vadakpat at *g.vadakpat@dot.gov* or 202-493-3283.

Ultra-high performance concrete (UHPC) has long been used for new construction in connections between prefabricated bridge elements. In the last few years, its use in bridge repair and preservation has increased as well. Here, crews install the first U.S. deployment of UHPC as a bridge deck overlay on a reinforced concrete slab bridge located in Brandon, IA, completed in May 2016.

Source: FHWA.

by **ZACHARY B. HABER**

You do not have to work in the surface transportation sector in order to be aware of the state of repair of many of the highway bridges in the United States. News headlines often contain the word "infrastructure" along with "crumbling" or "deteriorating." But those stories do not always include a description of what individuals and agencies are doing to effect change and spur innovation in the area of bridge preservation.

The Federal Highway Administration's *Bridge Preservation Guide* (FHWA-HIF-18-022) defines bridge preservation as "actions or strategies that prevent, delay, or reduce deterioration of bridges or bridge elements, restore the function of existing bridges, keep bridges in good or fair condition, and extend their service life." Keeping highway bridges in a state of good repair is challenging and requires bridge owners to be vigilant. There are numerous factors to be considered, such as availability of funding, time, volume of an owner's inventory, age of the structures in that inventory, and service conditions.

Another challenge is the durability of traditional materials and methods used for bridge preservation and repair. If a bridge owner repairs an element of a bridge with a material that deteriorates within 5 years, the same issue will need to be readdressed soon. Bridge owners have a choice: repeat the same course of action in a continuous cycle, or seek out a different, potentially more innovative, resilient, and permanent solution. The latter option is what some bridge owners are choosing to do.

"As a bridge owner with constrained resources such as money and time to make repairs that impact mobility, we are always on the lookout for new technologies that can help us with long-lasting bridge preservation actions that are life-cycle cost effective," says James Nelson, director of the Iowa Department of Transportation's Bridges and Structures Bureau, and chair of the American Association of State Highway and Transportation Officials' Bridge Preservation Technical Committee.

Ultra-high performance concrete (UHPC) is a fiber-reinforced, cementitious composite material with mechanical and durability properties that far exceed those of conventional concrete materials. These properties have made it popular for bridge construction, especially for field-cast connections between prefabricated bridge elements. Bridge infrastructure preservation and repair is a new application of UHPC

that offers enhanced performance and improved life-cycle cost over traditional methods. FHWA will be promoting the use of UHPC for bridge preservation and repair over the next 2 years through the sixth round of the Every Day Counts (EDC-6) program (for more information, visit *www.fhwa.dot.gov/innovation/everydaycounts/edc_6*).

UHPC in Highway Infrastructure

It has been nearly 15 years since UHPC made its debut on a bridge construction project in the United States. Since its first deployment in 2006, the use of UHPC in U.S. bridge construction has increased significantly. Today, there are more than 250 bridges in the United States that employ UHPC. Most of these bridges use UHPC for field-cast connections between prefabricated bridge elements.

The rise in popularity can be attributed to a handful of factors. First, there is increased awareness on behalf of bridge owners and designers and more readily available technical guidance and support. This factor was greatly aided by FHWA selecting UHPC connections for prefabricated bridge elements for inclusion in EDC-3 and EDC-4. Second, in the past 5 years,

Find out where UHPC is being used near you!

FHWA created and maintains an interactive map (*https://bit.ly/UHPCMap*) that shows the locations and details of bridges in the United States that used UHPC in their construction. Each icon shown represents an individual bridge. By clicking on an icon, users can access information about the selected bridge, such as the year built, the bridge owner, and how UHPC was used on the structure. The interactive map also features other data visualization and filtering functions. For example, a user can search for bridges that have been repaired using UHPC.

Source: FHWA. © ESRI (for map image).

In 2017, the St. Clair County Road Commission in Michigan was the first to deploy an open-source UHPC mixture on a U.S. bridge. UHPC was used to repair the joints between the bridge's precast double T-beams.

© Andrew Tai and Sherif El-Tawil, University of Michigan.

UHPC has a proven history for use in connections for prefabricated bridge elements. The Florida Department of Transportation leveraged this fact in 2016 when it first used UHPC to repair an existing bridge with precast, prestressed adjacent slab units whose connections were failing. The agency removed the concrete in the failing connections and replaced it with UHPC.

© Florida Department of Transportation.

new UHPC suppliers have entered the U.S. market, increasing competition and technical advancement. Third, nonproprietary or open-source UHPC mixtures are becoming more readily available. Fourth, contractors are gaining experience with UHPC and specialized UHPC installers are emerging, which reduces contingency or risk-based costs associated with using UHPC in construction. Last and most important, UHPC connections for prefabricated bridge elements addressed a critical need: simple, constructable, and robust connection details that provide rapid installation, better durability, and long-term performance.

An Emerging Application, A Proven Technology

Some bridge owners are now addressing another critical need by turning to UHPC as a solution for bridge preservation, repair, and strengthening to maintain or extend the service life of bridge structures. As a repair solution, UHPC offers enhanced performance and improved life-cycle costs over traditional methods. Furthermore, UHPC can provide an optimum solution for some repairs because of its strength and durability. It can be used in situations that normally use conventional concrete or repair mortars, and even in some cases that typically use structural steel.

"UHPC has been a game-changer in our industry, particularly in accelerated bridge construction applications. I see UHPC having a similar impact on the repair and preservation of concrete structures," says Jason Hastings, chief of bridges and structures at the Delaware Department of Transportation (DelDOT).

Another attractive aspect of using UHPC for preservation and repair is that some repair projects are relatively small in scale and are viewed as low risk by the bridge owners. As such, repair applications have become an alternative entry point for bridge owners looking to generate institutional knowledge and familiarize local contractors with UHPC. For example, States such as California, Colorado, Connecticut, Florida, and Rhode Island all got their first experience deploying UHPC through a bridge repair application.

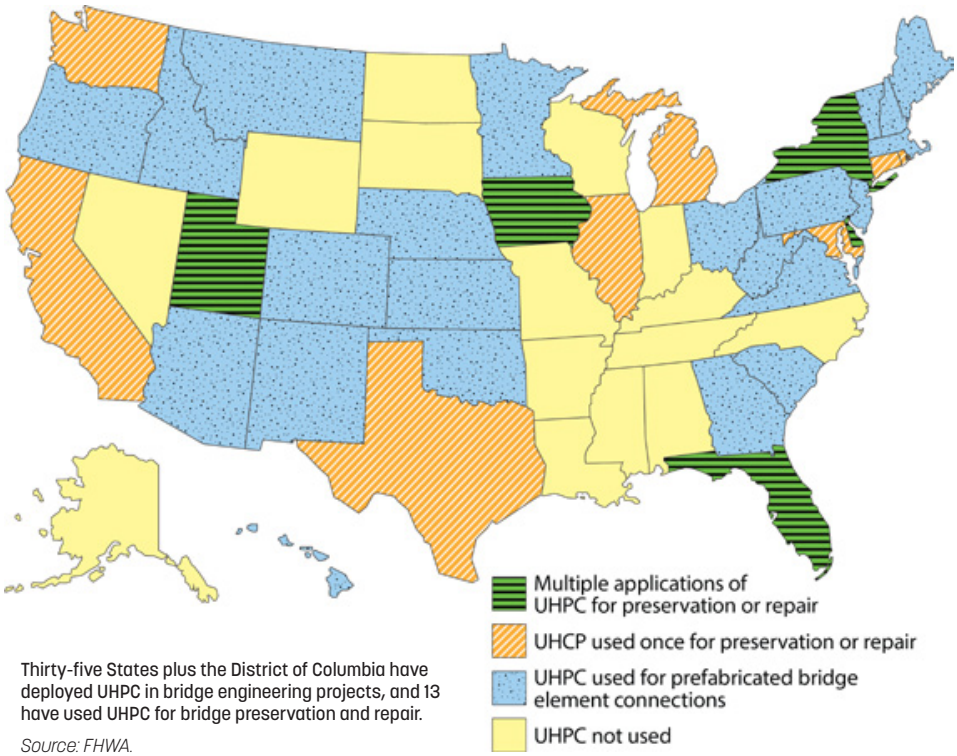
Early Adopters, Accessibility at All Levels

UHPC-based solutions can be used by local, State, Federal, and private transportation agencies, and, although some new knowledge is required, designers and contractors will be able to leverage their existing skill sets to deploy UHPC-based solutions. To date, more than 20 bridges in the United States have been repaired or strengthened using UHPC. Half of these projects were completed in 2019. As some States use repair applications to gain experience with UHPC, others have institutionalized UHPC-based repairs or made considerable investments to vet UHPC-based solutions. Furthermore, local transportation agencies have also played a role in the early deployment of this technology.

The New York State Department of Transportation (NYSDOT) is a great example of an agency that has institutionalized the use of UHPC for bridge repair.

"UHPC's proven ability to withstand the harsh environment our bridges experience here in New York State, combined with its versatility and high strength, make UHPC an ideal material for extending the service life of our bridges," says Jim Scarlata, a major projects engineer with NYSDOT's Structure Policy & Innovation Bureau.

NYSDOT has deployed UHPC link slabs on more than 20 bridges for both repair of expansion joints and new construction. Because of NYSDOT's commitment to advancing the use of this technology, other transportation agencies



Thirty-five States plus the District of Columbia have deployed UHPC in bridge engineering projects, and 13 have used UHPC for bridge preservation and repair.

Source: FHWA.

The University of Connecticut conducted extensive research on the uses of UHPC for beam end repair. Researchers load tested numerous large- and full-scale specimens with repaired steel beam ends, completed extensive computer simulations, and developed engineering design guidance.

© Kevin McMullen, University of Connecticut.

commonly look to the standard UHPC link slab details developed by NYSDOT as a point of reference.

The Connecticut Department of Transportation (CTDOT) took its own approach to deploying a UHPC-based repair solution. The agency invested in a multiyear research and development effort with the University of Connecticut and bridge engineering consultants to develop and vet the solution they needed prior to deploying it on a bridge. CTDOT needed a more efficient and cost-effective way to repair deteriorated steel beam ends, which corrode as a result of water laden with de-icing salt spilling down from leaky expansion joints. The agency installed its first beam end repair solution on an I–91 highway bridge in New Haven in 2019.

"The use of UHPC has transformed the way we look at the rehabilitation of deteriorated steel beam ends," says Andrew Cardinali, CTDOT's State bridge engineer. "It has opened the door to additional tools in CTDOT's toolbox to address the ever-growing problem of bridge maintenance."

Promising UHPC-Based Repair Solutions

There are a number of different UHPC-based preservation and repair solutions that have been deployed by State or local transportation agencies, or conceptualized and laboratory tested by university or Federal researchers. Some of these solutions include:

- UHPC overlays for bridge deck rehabilitation.
- Structural strengthening of deteriorated girder ends.
- Expansion joint removal and replacement using UHPC link slabs.
- Structural patching of reinforced concrete bridge decks, prestressed girders, and bearing pedestals.
- Repair of existing connections between prefabricated bridge elements.
- Expansion joint repair with UHPC header.
- Seismic retrofit of deficient bridge column-footing lap splices.

Some applications can extend the service life of bridges well beyond that of traditional repair strategies and are more cost efficient than bridge replacement. For example, UHPC overlays for highway bridge decks are gaining attention from State, Federal, and privately owned toll bridge authorities due to their potential for extending the service life of bridges. UHPC overlays have been extensively used in Europe with much success, and were first deployed in the United States in Iowa in 2016.

DelDOT was an early adopter of UHPC overlay technology and has implemented this solution on multiple bridges in the State. "We have installed a couple of UHPC overlays in Delaware, and we see them [having] a significant role in extending the service life of bridges," says DelDOT's Hastings.

Other promising solutions, which FHWA will be emphasizing through its EDC-6 deployment of UHPC for preservation and

UHPC overlays are an emerging solution for enhancing the durability and extending the service life of highway bridge decks. Typically, UHPC that has been specially formulated for overlay applications can be applied to the bridge after deteriorated concrete has been removed and the deck surface roughened.

Source: FHWA.

Fresh UHPC can be finished using a vibrating screed bar or more specialized equipment.

Source: FHWA.

repair, are UHPC link slabs and beam end repair. Both solutions have immense potential to advance current practices related to the repair of failing expansion joints and the associated maintenance challenges they cause.

"NYSDOT has found UHPC to be an excellent material for link slabs due to its capability to accommodate high tensile strains, exceptional bond to existing concrete and rebar, and extremely low permeability," says NYSDOT's Scarlata.

Addressing Needs through Applied Engineering Research

With any new technology, there will be a learning curve, new challenges, and new questions that require answers. Luckily, FHWA is well positioned to provide support.

"FHWA's research branch, the Turner-Fairbank Highway Research Center (TFHRC), has a track record of developing innovations, then delivering them to stakeholders," says Benjamin Graybeal, the leader of the Bridge Engineering Research Team within FHWA's Office for Infrastructure Research and Development. "Based on our years of success with UHPC-based concepts, we will provide technical support to our partners as they engage this promising set of preservation and repair solutions."

Since 2016, researchers at TFHRC have been working to address questions from early adopters of UHPC for preservation and repair. TFHRC staff have been developing technical guidance and best practices by executing laboratory-based, applied engineering research. Much of this work is influenced and carried out by forming collaborations and partnerships with transportation agencies and stakeholders.

For example, a few months after the installation of the first UHPC overlay in the United States, researchers from TFHRC visited the Iowa bridge site to conduct field testing of the UHPC overlay to assess the installation quality. The findings of this work and subsequent research have been published and have been used to develop UHPC overlay installation guidance (see *Field Testing of an Ultra-High Performance Concrete Overlay* [FHWA-HRT-17-096] and *Ultra-High Performance Concrete for Bridge Deck Overlays* [FHWA-HRT-17-097], for example).

Moving Forward with EDC-6

FHWA has a strong, proven history of providing technical assistance and outreach on UHPC. UHPC for prefabricated bridge element connections was an innovation included in EDC-3 and EDC-4, and it was a highly successful effort by bridge engineering stakeholders, TFHRC, and FHWA as a whole. Yet this technology is still being underused when compared to its transformative potential. Bridge preservation and repair is also an area where UHPC can have a dramatic impact.

In 2020, FHWA selected UHPC for Bridge Preservation and Repair as one of the technologies to be included in EDC-6, which runs throughout 2021 and 2022. Under the EDC banner, FHWA is ready to

Replacing deteriorated, leaky expansion joints with UHPC link slabs offers bridge owners a maintenance-free, permanent solution.

LEFT: First, the existing expansion joint and some of the surrounding concrete must be removed. CENTER: Workers install components of the new link slab, such as new steel reinforcing bars and UHPC. RIGHT: The cured UHPC link slab is ground to match the profile of the existing deck and grooved for skid resistance.



Deterioration of steel bridge girder ends is a prevalent challenge for bridge owners in the northeastern part of the United States.

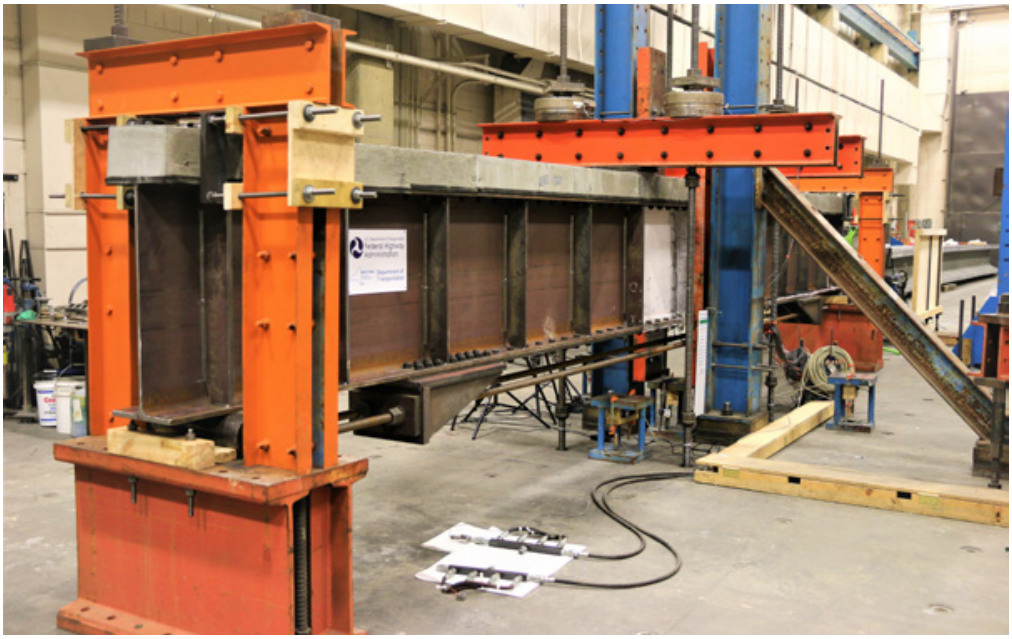
LEFT: Rusting steel leads to section loss, compromising the strength of the steel beam. CENTER: To strengthen the deteriorating steel, before adding UHPC, a worker welds headed shear studs to the remaining quality steel. RIGHT: The end region is encased in field-cast UHPC, resulting in a strong and durable repair.

© University of Connecticut.

assist States and especially local partners in maintaining and preserving their bridges using proven UHPC preservation and repair solutions. This initiative will focus on a suite of UHPC-based preservation and repair solutions, with an emphasis on solutions that have the most promise, such as UHPC overlays for bridge decks, UHPC link slabs for repair of failing expansion joints, and UHPC for repair of deteriorated steel beam ends.

To support the deployment of this initiative, FHWA is developing a guidance document entitled *Design and Construction of UHPC-Based Bridge Preservation and Repair Solutions*, which is scheduled for publication in 2021. The document will provide a background on UHPC-class materials, discuss common applications of UHPC for preservation and repair, provide design guidance and commentary, and offer a few case studies on successful projects. The document will serve as a cornerstone for other technical assistance and outreach efforts.

Other planned activities include virtual or in-person 1-day workshops for State and local transportation agencies, a four-part national webinar series, and development of training content for local agencies and contractors. Transportation agencies interested in hosting a UHPC preservation and repair workshop should contact their FHWA division office or Zachary Haber.



Collaboration is a critical aspect of advancing new technology in civil infrastructure. In 2019, researchers at TFHRC's Structures Lab tested an innovative UHPC-based strengthening method to increase structural strength of riveted steel thru-girder bridges. This was a collaborative effort between FHWA and NYSDOT, which was looking for a unique solution and which has partnered with FHWA in the past for research-to-deployment projects.

Source: FHWA.

ZACHARY B. HABER, Ph.D., is a research structural engineer with the Office of Infrastructure Research and Development at FHWA's Turner-Fairbank Highway Research Center. Dr. Haber leads research and provides technical assistance on topics related to UHPC, conventional structural concrete, bridge engineering, and seismic design. He holds a doctorate in civil engineering from the University of Nevada, Reno.

For more information on FHWA's EDC deployment of UHPC for preservation and repair of bridges, contact Zachary B. Haber at *zachary.haber@dot.gov* or Mark A. Leonard at *mark.leonard@dot.gov*. For more information on FHWA's UHPC research activities, contact Benjamin A. Graybeal at *benjamin.graybeal@dot.gov*.

Risk exists throughout an organization, at the enterprise, program, project, and activity levels.

Source: FHWA.

HANDLING RISK: FHWA'S INTEGRATED APPROACH

FHWA is working to make the organization more effective and efficient by applying an enterprise risk management framework that combines strategic planning, performance planning, and internal controls.

by **DANIEL FODERA**

Over the years, government operations have changed dramatically, becoming increasingly complex and driven by changes in technology. At the same time, stakeholders expect greater program integrity, efficiency, and transparency in government operations within existing resource constraints.

In response, Federal agencies are implementing enterprise risk management, an approach that brings together risk management, strategic and performance planning, and internal control processes. Implementing enterprise risk management engages an organization across all mission and mission-support functions to improve efficiency, effectiveness, and compliance.

"For the Federal Highway Administration, enterprise risk management is the latest step in the agency's journey of continuous improvement," says Peter Stephanos, FHWA's acting Chief Strategy Officer. "What is new is the integrated approach between strategic planning and review, internal control, and risk management."

Using Risk Management To Focus on Results

Strategic and performance planning gained traction in 1993 after Congress required Federal agencies to focus on performance by developing long-term and annual goals, then measuring and reporting on progress toward those goals. The intent was to shift Federal Government focus from program activities and processes to a focus on desired results.

To achieve successful outcomes and fulfill an organization's mission, policymakers and program managers continually seek ways to improve accountability. A key factor in improving accountability is implementing an effective internal control system. Doing so helps the organization adapt to shifting environments, evolving demands, new priorities, and changing risks by applying risk management techniques.

Risk management has been a part of FHWA's approach to stewardship and oversight for two decades. In 2001, FHWA policy called for each office to conduct risk/benefit assessments to evaluate the implementation of FHWA programs and develop work plans consistent with the results. The policy aimed to enable flexibility for FHWA offices in tailoring a process with their partners. As FHWA and its partner agencies became more familiar with the risk/benefit assessment process, FHWA issued additional guidance on how to manage risk.

What Makes ERM Work?

Governance	Objectives	Operating Principles
Making decisions at the corporate level	Knowing what we are striving to achieve	Knowing where we accept and avoid risks
Assessments	**Planning**	**Monitoring**
Routinely evaluating our actions	Clearly communicating critical activities and reduced effort	Tracking indicators against tolerances to assess progress

Source: FHWA.

Managing Risk in the Recovery Act

FHWA used a risk management approach in the successful delivery of the American Reinvestment and Recovery Act of 2009. In order to deliver projects quickly, the $787 billion Recovery Act released an additional $27.5 billion for highway projects across the Nation. Although the highway portion represented a small part of the total program, it was highly visible. The visibility, rapid influx of dollars, economic environment, and Federal reporting requirements gave rise to a challenging risk environment.

Some of the specific risks included projects administered by local public agencies—some of which were unfamiliar with Federal requirements related to contract administration, environmental compliance, civil rights program requirements, and project reporting. FHWA took a national, strategic approach and responded to these risks by increasing communications, providing additional resources, and conducting onsite reviews of projects to identify and resolve issues. Federal-aid divisions identified risks within each State and tailored their risk response activities to their environment. Division and national engineers and technical specialists worked to identify and effectively address risks to individual projects. The result was that FHWA successfully delivered the Recovery Act projects by addressing risks at multiple levels of the organization.

Risk Management at All Levels

The multilevel approach to the Recovery Act exemplifies how an organization manages risk. Effective organizations manage risk at the enterprise, program, project, and activity levels.

Risks at the enterprise level affect the entire organization. They may be external strategic risks or internal risks that cut across units or multiple programs. Programs comprise the groups of related projects, subsidiary programs, and program activities. Coordinating and managing risk at a program level provides benefits not available from managing these activities individually. Projects comprise temporary endeavors undertaken to produce a unique product, service, or result. Individual projects may have unique risks to their success. Activities involve a coordinated set of ongoing actions

Part of risk management is knowing when to accept or avoid threat risks, and when to pursue opportunities.

Source: FHWA.

FHWA Risk Management Process

Source: FHWA.

taken to support projects or programs. There are risks at the activity level too.

The responsibility for managing risk at each level lies with the managers or leaders responsible for the success of that part of the organization. Enterprise-level risk is managed by the senior executives, program risk by the program managers, project risk by the project managers, and activity risk by those responsible for that activity.

"The process for managing risk is consistent regardless of whether it's being applied at the enterprise, program, project, or activity level," says Brian Bezio, FHWA's Chief Financial Officer.

This consistency in the core process can also be seen in the different standards or guides for risk management—such as ISO 31000:2018, the Project Management Institute's Project Management Body of Knowledge, or OMB Circular No. A-123, "Management's Responsibility for Enterprise Risk Management and Internal Control." The process includes communication and consultation, understanding the risk context, risk assessment (identifying, analyzing, prioritizing), responding to risk, and monitoring the results. An important consideration in applying the risk management process is the organization's attitude toward risk—its risk appetite.

Risk Appetite

Risk appetite is the type and amount of risk, on a broad level, that the agency is willing to accept in pursuit of program objectives. Explicit risk appetite statements aid units in understanding when an organization will and will not accept risk in order to achieve goals and objectives. In addition, risk appetite describes how an organization will respond to risk, including the subsequent actions undertaken as a result.

Risk appetite informs decisionmaking. It represents risk posture at the enterprise level, and the absence of a risk appetite statement does not imply that there are not other risks that the agency also faces. FHWA has developed risk appetite statements with the intention that they will evolve over time in response to changing priorities and internal and external contexts.

FHWA risk appetite statements describe opportunities the agency is willing to pursue to help achieve goals and objectives. Acceptable risk means that the benefits of pursuing certain opportunities outweigh the potential threats. For example, transferring certain responsibilities to recipients when effective controls are in place and pursuing the deployment of innovations could realize long-term benefits to transportation, and those benefits could outweigh the risks. Each statement contains conditions that must be met when taking on these risks.

The FHWA risk appetite statements also describe how the agency will respond to threat risks. These are situations where threats, if realized, could have adverse impacts to public safety, system resiliency, the Federal investment, and FHWA's credibility.

Risk Management at FHWA

FHWA applies the risk management process across the enterprise to develop strategic plans every few years and unit performance plans each year. The agency integrates strategic planning, performance planning, and risk management into the performance planning cycle. The cycle begins with the establishment of program objectives and risk appetite. The FHWA leadership team establishes risk appetite and agency-wide program objectives that align to the strategic objectives.

Program offices assess program areas to evaluate efficiency, effectiveness, and compliance at a national level. These program assessments validate or identify critical activities to be undertaken by the agency. They also identify areas to reduce effort or improve efficiency and use of agency resources. The program offices apply the program and risk assessment process to involve stakeholders, offices, and individuals from across the agency. The program offices, coordinating with the Chief Strategy Officer, bring the results of these assessments to the FHWA leadership team, which then communicates them to the agency as draft activities.

Units provide comments on the draft activities that provide important perspective and are considered in developing a final enterprise performance plan. Units conduct risk assessments to evaluate opportunities

Identifying Program Objectives

Defining objectives at the appropriate level of the organization is an essential component of the enterprise risk management framework. By definition, risk represents the effect of uncertainty on objectives, so risk management cannot be effective if objectives are unclear, undefined, or inconsistently understood. FHWA uses its enterprise risk management to explicitly define objectives for Federal Highway programs.

Program objectives support the achievement of FHWA strategic goals and objectives. They provide a consistent framework for understanding risk and developing activities across the organization. The agency evaluates the risks to achieving its program objectives and prioritizes responses based on risk appetite.

and threats to achieving program objectives, assigned critical activities, and available resources. By using the risk management process and applying risk appetite throughout, units identify, evaluate, and prioritize their risks and develop response strategies to address the top risks. The risks identified by FHWA for programs and projects are managed in consultation with State partners within the context of a federally-assisted, State-administered program.

The finalized annual unit performance plans include significant activities for the coming year, critical activities, and responses to top risks. Units implement plans, monitor results, and reassess risks. The program offices and FHWA leadership team monitor and consider performance results and risks, which become part of the organizational context as the cycle repeats.

Managing risk involves paying attention to factors that affect the work, monitoring results, and making adjustments in how to focus resources.

Source: FHWA.

Framing the Future

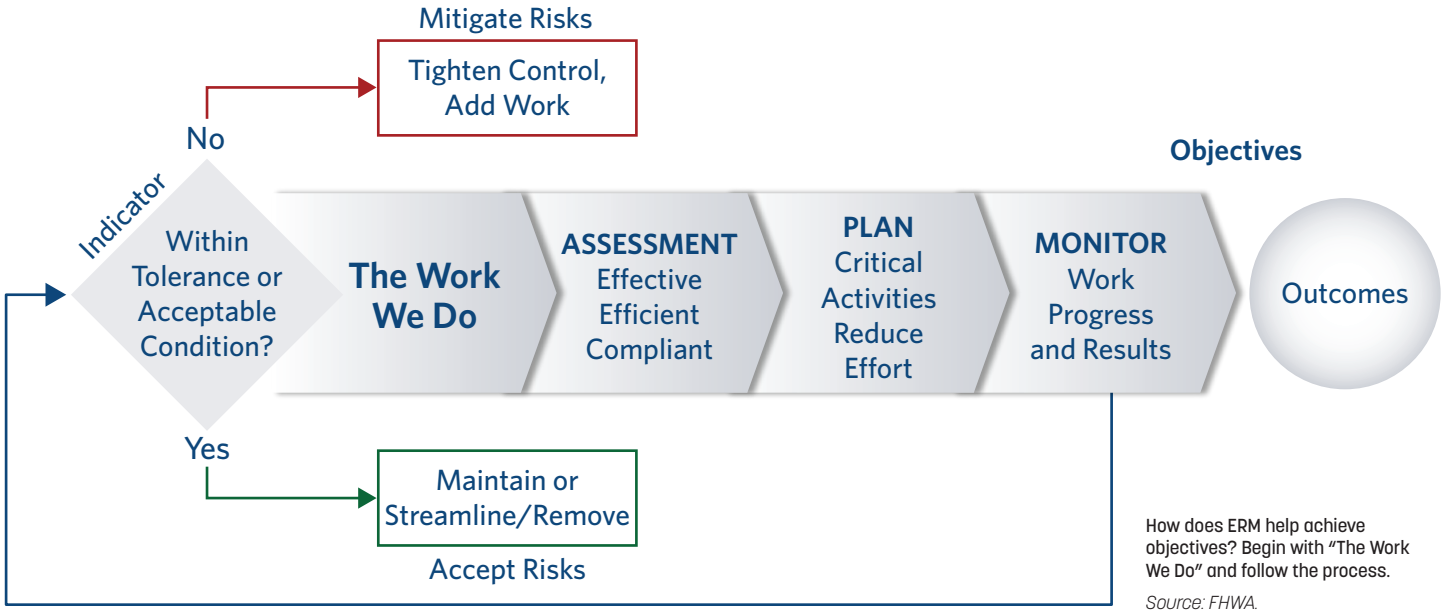
The enterprise risk management framework establishes a consistent approach to identify, assess, and prioritize threats and opportunities so that FHWA can decide how to address future issues affecting the Federal-aid and Federal Lands Highway Programs and national objectives. The framework helps to focus limited resources, strengthen the ability to efficiently and effectively manage programs, and communicate consistently about what the agency should focus on and why. Enterprise risk management helps to provide reasonable assurance that FHWA understands the risks associated with achieving objectives and responds appropriately.

"Enterprise risk management is about making risk-based corporate decisions to most effectively and efficiently carry out our programs," says Thomas Everett, FHWA's Executive Director. "Through ERM, we will better understand when we should be involved and when we can reduce effort in our program and project level actions. By considering our appetite for risk and by assessing our programs, we can make these decisions in a more informed manner."

DANIEL FODERA is the corporate performance and risk management officer in FHWA's Office of Stewardship, Oversight, and Management. He has held positions in field offices and headquarters. Daniel holds one U.S. patent and is a Certified Enterprise Risk Manager. He holds a master's degree in public administration from the University of Maryland Global Campus (Europe) and a Master Black Belt Certificate in Lean Six Sigma from Villanova University.

For more information, contact Daniel Fodera at 404-562-3672 or *daniel.fodera@dot.gov*.

ERM in Practice: Operating Principles



How does ERM help achieve objectives? Begin with "The Work We Do" and follow the process.

Source: FHWA.

The welds between steel plates on bridge girders are critical to the strength and integrity of the bridge. Advances in nondestructive evaluation techniques like ultrasonic testing may help both manufacturers and field inspectors identify and address flaws safely and accurately.

by **HODA AZARI** and **RUSSELL KOK**

The welds between steel plates are critical components of steel girders in bridges. They must be welded and inspected carefully, and to ensure the integrity of the girder, inspectors use nondestructive evaluation (NDE) methods. However, the high levels of radiation needed for the historic approach, radiographic inspection, can present a safety and work area disruption concern for fabricators. Ultrasonic inspection presents an alternative NDE method.

The American Association of State Highway and Transportation Officials/American Welding Society (AWS) D1.5M/D1.5 Bridge Welding Code establishes the rules for weld inspection, including which NDE methods can be used, what types and sizes of flaws need to be repaired, and more. Steel bridge girders comprise fabricated assemblies of built-up steel plates welded together in fabrication shops. For the evaluation of potential subsurface flaws in the welds, two NDE methods are used: radiographic inspection and ultrasonic inspection.

Why Use Ultrasonic Inspection?

Historically, fabricators have used radiographic methods to inspect welds. This technology dates back to the 1930s, and over time has become the baseline approach to inspect bridge welds. Whereas medical radiology uses a low-dose radiation source to expose a film or digital imaging plate to get an image of a broken bone, the thick steel welds require much higher energy radiation levels and doses to penetrate the weld and produce an image. These high radiation levels present a safety and productivity problem for fabricators.

Ultrasonic inspection methods have been available since the 1960s; however, many bridge owners do not yet accept them with confidence. While ultrasonic methods can be used for some less critical welds, other welds still require the cumbersome and dangerous radiography. Certified inspectors perform conventional ultrasonic testing by manipulating a handheld single-element probe around the weld and use their training and experience to detect and evaluate any weld flaws. This can be a subjective process that varies between inspectors, and is one reason bridge owners and code-writing authorities hesitate to fully accept the method. Also, bridge owners have more confidence in radiography because they can

A worker performs an ultrasonic inspection of a weld in a steel fabrication shop.

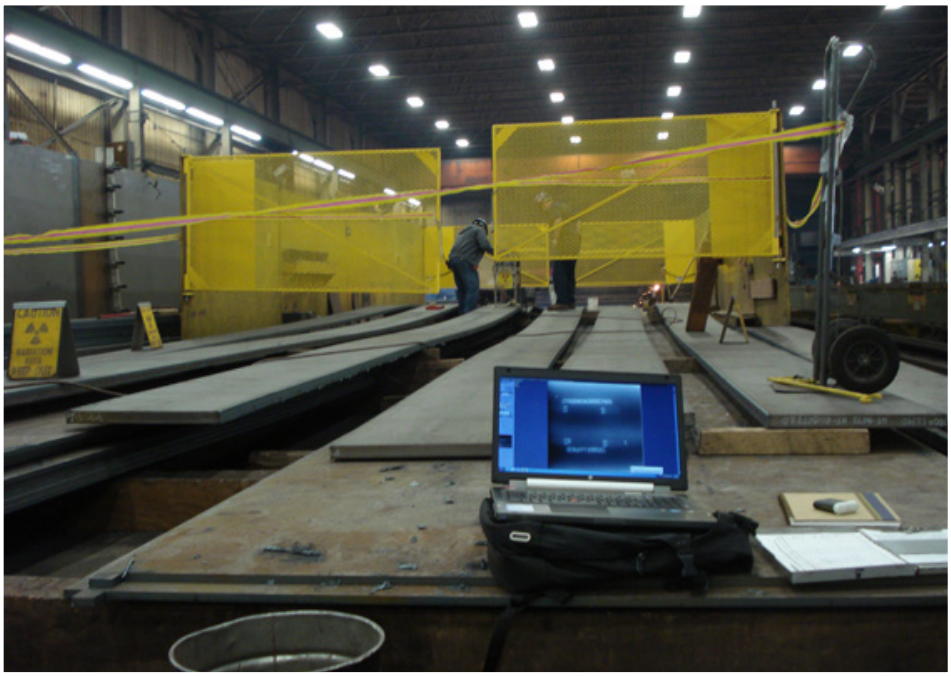
© High Steel.

see the weld images themselves, whereas with conventional ultrasonic testing, they only get a documented report without images or other data.

Just as medical ultrasonic imaging has evolved with faster computing power and the resulting higher resolution images, industrial ultrasonic technology has followed with similar improvements. Phased array ultrasonic testing (PAUT) uses probe arrays in lieu of single-element probes and position encoders to capture the scan data and produce images of the inspection results, similar to a radiographic image. The probe array produces a fan of sound rather than the single sound beam used in conventional ultrasonic testing. This results in a more productive inspection because more weld volume can be inspected at one time, and, in conjunction with the stored scan data and encoder information, an inspector can produce an image of the scan, which adds confidence in the inspection results.

The latest development in PAUT testing is a more advanced image processing method called full matrix capture. This innovation can use the same basic instrument and probe, but offers new software processes to create a higher resolution image of any flaws.

The Federal Highway Administration's Advanced Sensing Technology (FAST) NDE Laboratory has been conducting research activities to explore PAUT and full matrix capture NDE techniques. The NDE laboratory is part of FHWA's Turner-Fairbank Highway Research Center in McLean, VA. The lab's PAUT research directly supports the overarching goal to support the implementation of ultrasonic techniques in lieu of radiographic techniques for AASHTO/AWS D1.5 Bridge Welding Code inspection of full penetration bridge fabrication welds.



Radiation boundaries in a fabrication shop help keep workers safe from the high levels of radiation needed to radiographically inspect welds.

© High Steel.

PAUT enables inspectors to capture data and produce images similar to a radiographic image.

© High Steel.

When Can PAUT Be Used?

The 2015 D1.5 Bridge Welding Code added an annex, "Advanced Ultrasonic Examination," as a means to integrate PAUT into inspection workflow as a substitute for radiographic testing, pending approval of the substitution by the engineer. The annex provides requirements for the use of PAUT to inspect bridge fabrication welds in lieu of the historic single-transducer, manual ultrasonic testing allowed by D1.5 for decades.

The D1.5 code permits ultrasonic testing inspection for some full penetration bridge welds, but still requires that welds subjected to tensile or reversal stresses be inspected by radiographic testing. Butt welds in fracture critical members, welds made by the electroslag welding narrow gap process, and electrogas welding also require both radiographic and ultrasonic testing.

While the D1.5 code approves some applications of PAUT, there are still applications that require further investigation and validation of the performance of PAUT to potentially replace the cumbersome and costly radiographic testing method. The overall objective of the continuing PAUT work at the FAST NDE Laboratory is to evaluate the state of PAUT technology and its potential application as an alternative to all radiographic testing in D1.5.

Implementation of a PAUT program is a big step beyond manual ultrasonic testing. The benefits of moving to PAUT can result in more efficient and reliable inspections. While the general approach to ultrasonic testing of a weld is similar, PAUT is a more complex inspection process that requires an upfront investment in equipment and software, as well as the need for additional inspector training.

Exploring PAUT in the Lab

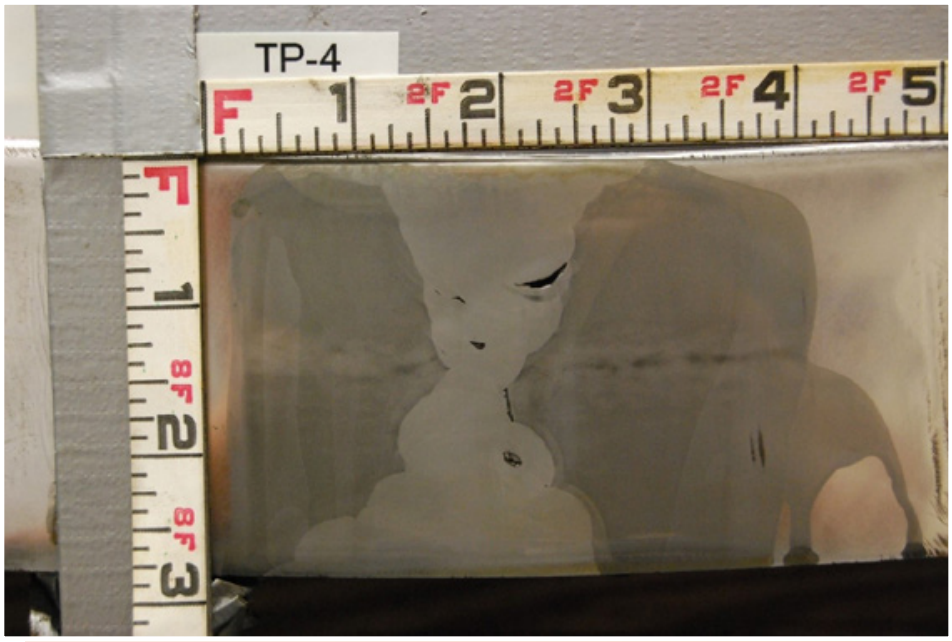
The FAST NDE Laboratory has been investigating PAUT technology for several years, including prior to the publication of the "Advanced Ultrasonic Examination" annex. The first phase of these investigations involved the fabrication of suitable test specimens and development of preliminary procedures. Bridge fabricators prepared welded test specimens to ensure that they represented commonly applied bridge fabrication welding techniques. They fabricated full penetration butt joints and transition butt joint specimens. The welders intentionally implanted weld defects such as porosity, cracks, lack of fusion, and slag in the test specimens.

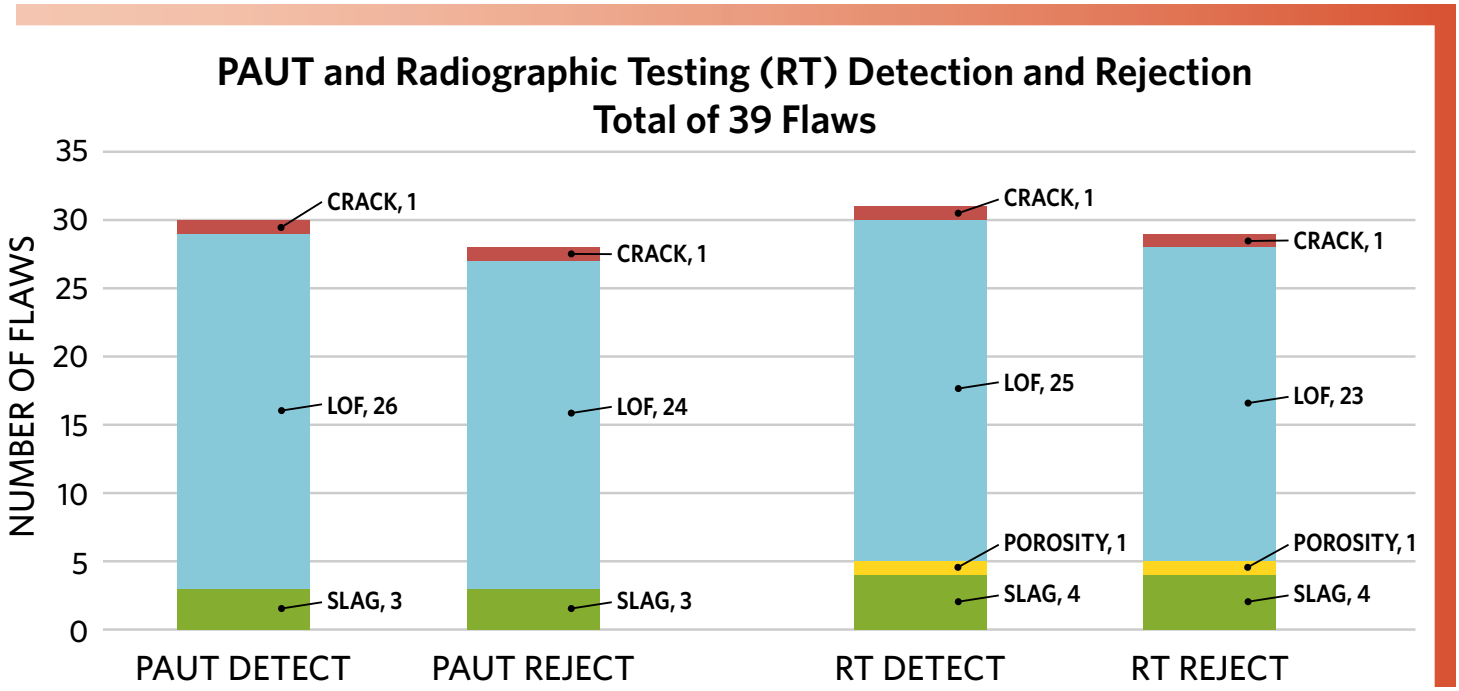
The initial comparisons of the results from PAUT, conventional ultrasonic testing, and radiographic images provided a broad understanding of the effectiveness of PAUT. The results from PAUT generally agreed with the radiographic results on each of the test specimens, supporting the decision to continue the PAUT investigations.

The next phase of the study was an effort to continue to create PAUT requirements and support the development of PAUT acceptance criteria for proposed incorporation into the D1.5 specification. FHWA presented highlights of this early work to the AWS committees, along with contributions from many other participants supporting the committee, which resulted in the 2015

FHWA fabricated specimens like this test plate to use in comparing PAUT and radiographic techniques. The test plate shown here has a submerged arc weld, and the section lies at the end of the plate where the runoff tab has been sawed off. These flaws do not necessarily represent the flaws along the entire length of the weld.

Source: FHWA.





This chart illustrates the good comparability of detection and rejection of flaws using PAUT and radiographic testing in the lab. This set of test plates had 39 flaws, including cracks, lack of fusion (marked LOF on the chart), porosity, and slag. The detection and rejection results for the two methods are nearly identical for this particular set of test plates.

Source: FHWA.

adoption of the annex PAUT requirements in D1.5.

Researchers selected commonly available off-the-shelf PAUT equipment and transducers for the data collection and analysis. FHWA used a 64-element, 2.25 MHz linear array probe. While the AWS D1.5 requirements do not limit the probe frequency to the 2.25 MHz range as they do for manual ultrasonic inspection, researchers chose 2.25 MHz to better compare the results to manual inspection results.

FHWA performed the PAUT calibration in accordance with D1.5. The calibration block includes a series of 1/16-inch (1.6 millimeter) diameter side drilled holes at different depths to set a uniform inspection sensitivity throughout the thickness of the weld to be examined. This is a very different approach to calibration compared to the manual ultrasonic testing inspection requirements in D1.5, where a single side drilled hole is used. With manual D1.5 ultrasonic testing, the correction of inspection sensitivity as the sound attenuates through the material is calculated using an assumed sound attenuation rate. Currently, the AWS committee is discussing which approach is better for calibration because both have their pros and cons.

The research team fabricated test specimens to be representative of the materials, weld joint designs, thicknesses, and weld processes typical in bridge fabrication. To ensure that the welding would represent production bridge welding practices, the specimens were manufactured by two steel bridge fabricators using electroslag welding narrow gap and submerged arc welding processes. The fabricators attempted to implant natural defects in the specimens that could typically be encountered during the manufacturing process, such as cracks, lack of fusion, lack of penetration, porosity, and slag. FHWA fabricated a total of 10 butt joint specimens.

NDE Lab Results

The research team found that PAUT and radiographic testing had comparable rates of detection and rejection of flaws. Out of the total 39 discontinuities in the data set, radiographic testing rejected 5 flaws accepted by ultrasonic testing, and ultrasonic testing rejected 4 flaws accepted by radiographic testing.

The largest flaw rejected by PAUT and missed by radiographic testing was a 5-inch (13-centimeter)-long defect suspected to be caused by lack of fusion. The largest flaw rejected by radiographic testing but accepted by PAUT was a 1.88-inch (4.78-centimeter)-long defect caused by lack of fusion. PAUT detected this lack of fusion, but at a signal amplitude below the threshold requiring evaluation per AWS D1.5.

While missing a lack of fusion almost 2 inches (5 centimeters) long may raise questions about the reporting threshold in AWS D1.5, welds can exhibit low amplitude discontinuities of this length. In NDE, thresholds are always needed to avoid the unnecessary evaluation of every small signal detected, and the AWS approach is based on the fact that low-amplitude signals have not been found historically to be detrimental. The radiographic testing process missing a 5-inch (13-centimeter)-long lack of fusion raises greater questions about the reliability of radiographic testing to detect that flaw. The NDE community understands the issue as a generally known weakness of radiographic testing.

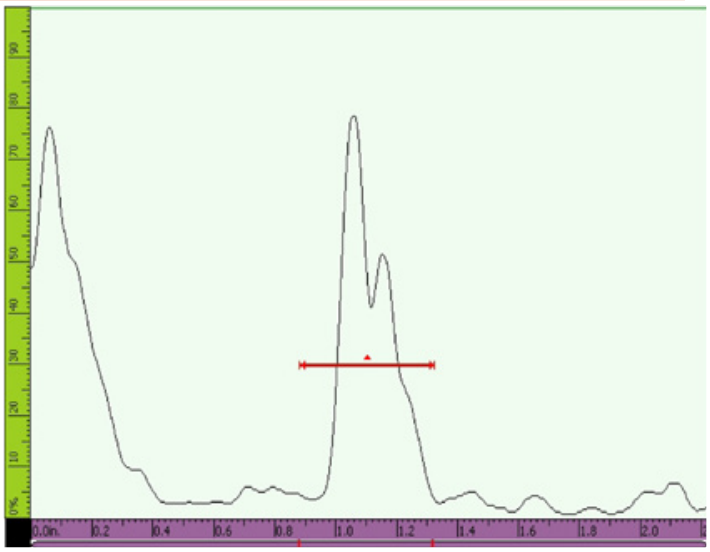
The overall goal of FHWA's ongoing research effort is to establish whether PAUT is a viable alternative to the use of radiographic testing. The initial results—indicating a good correlation of the comparative inspection results between PAUT and radiographic testing—support PAUT as an alternative. However, there is a need to develop a more comprehensive set of weld flaws to ensure that researchers can evaluate a fully representative flaw set. Consequently, the FAST NDE Lab is currently using ultrasonic simulation software to supplement the test plate data with a virtual database of simulated flaws. The researchers will also model and use physical test plate flaws to validate the modeling results.

Advances in PAUT Techniques

Although D1.5 added the annex with PAUT requirements in 2015, the AWS committees continue to receive feedback to improve the requirements, incorporate evolving technology, and address lessons

To illustrate the difference in the visual display capabilities of ultrasonic testing methods, FHWA's NDE Lab created this steel block with three sets of three holes with 1-millimeter diameters, and scanned it using different techniques.

Source: FHWA.



Scanning the steel block using historic methods of ultrasonic testing with a single-element probe results in a display like this one. The peaks represent the holes; the two peaks in the center of the display are two of the three holes in the middle set.

Source: FHWA.

learned from early adopters of PAUT in the bridge fabrication community.

The latest advances in industrial ultrasound use full matrix capture and total focusing method PAUT techniques. These techniques employ the same basic PAUT instruments and probe arrays used for conventional PAUT, but they process the image data in ways not previously possible because of limitations in computer processing power.

To illustrate the capabilities of the evaluation and imaging techniques of various methods, FHWA conducted activities using a steel block with a series of closely spaced holes of 1 millimeter in diameter drilled in the sides, in three groups of three holes. The location of the holes presents a challenge to traditional ultrasonic testing methods using a single-element transducer, which cannot produce an image of high enough resolution to indicate all the holes.

Using conventional PAUT testing with an unfocused sound beam—used when an entire weld is being inspected without knowledge of any existing flaws—creates an image indicating the three groupings. Rescanning with a focused sound beam—used for greater detail once the location and depth of a flaw are discovered—provides an even clearer image. Finally, using the more advanced PAUT full matrix capture technique—which does not require focusing at a known depth—creates the image with the greatest clarity showing the three groupings of three holes each.

The research team collected all of the PAUT and PAUT full matrix capture data with a 60-element straight beam 2.25 MHz probe in order to highlight the differences in imaging technology. Different frequency and different size probes will change the resolution of an image.

The ultrasonic sound beam path analysis carried out to develop the PAUT scan plans indicates that there is a need to conduct a minimum of two scans along each side of the weld at different probe index point offsets from the weld centerline to ensure complete volumetric coverage of these relatively thick welds. This scanning approach is applicable to both straight thickness butt welds and transition thickness butt welds.

The large-grain microstructure observed in electroslag welds did not influence the propagation of ultrasonic waves to a point where it affected the detectability of the implanted flaws.

Two key benefits result from the use of full matrix capture and total focusing method technology. The first is better weld flaw detection and characterization producing an image much more representative of the actual flaw shape than what can be visualized with previous ultrasonic tests. The second is better flaw sizing, supporting more advanced engineering analyses to evaluate whether a flaw needs to be repaired, which is particularly applicable to in-service bridge inspections where costly repair decisions are required.

Pennsylvania DOT Perspective

In 2017, the Pennsylvania Department of Transportation (PennDOT) procured a PAUT instrument. The agency's primary focus to date is to determine the feasibility of substituting PAUT for radiography by conducting numerous assessments of capability and limitations. PennDOT is looking to potentially replace the current testing practice for full penetration welds in a fabrication setting.

"Analyzing the results with the current workmanship standards, the data [have] shown a promising comparison to that of the radiographic method in place today in terms of length and detection," says Nicholas Shrawder, a civil engineer at PennDOT. "While it is understood that we will never get a true one-to-one comparison, the advantages of evaluating the change from radiographically to ultrasonically testing welded splices include eliminating potential radiation hazards, ability to better detect flaw types deemed more critical, and retention of an image for a permanent record much like that of radiography."

"Full matrix capture/total focusing method is without question the next generation of PAUT for more accurate sizing and discontinuity characterization," says Shrawder. "PennDOT has been closely monitoring the technology as it progresses."

PennDOT is evaluating a pilot project to be launched in 2021 assessing another advanced technology feature of PAUT for data analysis via market-available software using advanced algorithms for interpretation and reporting.

USACE's Perspective

The U.S. Army Corps of Engineers (USACE) is responsible for the maintenance and operation of thousands of steel bridges and hydraulic steel structures. The structures are steel gates used to maintain navigation

pools, operate locks, and maintain reservoir storage for flood risk management and hydropower operations. Maintaining these assets becomes an ever-increasing challenge given decreasing operating budgets and the increasing age of the infrastructure. Structural failures can result in loss of life, as well as negative economic impacts. USACE continually searches for methods and tools to extend the service life of these structures while maintaining safety and operability.

One approach is to evaluate a structure for fitness for service, which is defined as the ability to demonstrate the structural integrity of an in-service component containing a flaw or damage. For welded steel structures, this means detecting and quantifying flaws and evaluating acceptability through the application of fracture mechanics.

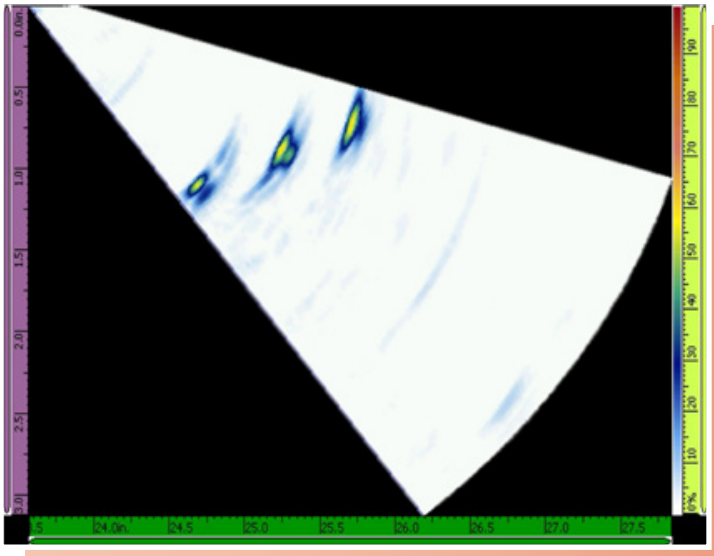
"Ultrasonic testing is a useful tool for sizing or quantifying embedded flaws and the extents of surface flaws," says Phillip Sauser, a structural engineer with USACE. "Traditionally, single-probe, pulse-echo ultrasonic testing has been used and has given acceptable results when used by highly skilled operators. The challenge has been finding and procuring operators of this skill level."

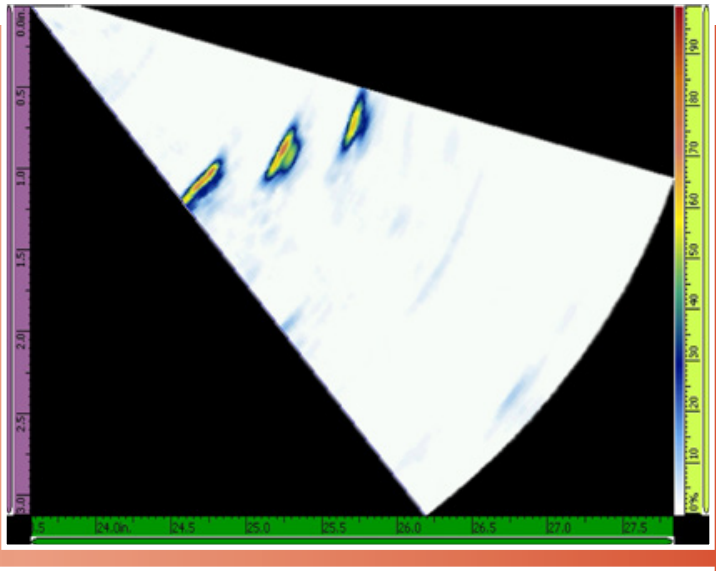
Recently, USACE has been investigating more advanced testing methods including PAUT and time-of-flight diffraction. Initial PAUT studies showed a wide variation of results, with some measurements within less than 1 percent of actual size and others as much as 300 percent greater than actual size. These studies found that the greatest accuracy often comes with scanning both faces of the member from both sides of the weld, conducting multiple scan offsets from each face and each side, and rastering to maximize signal return.

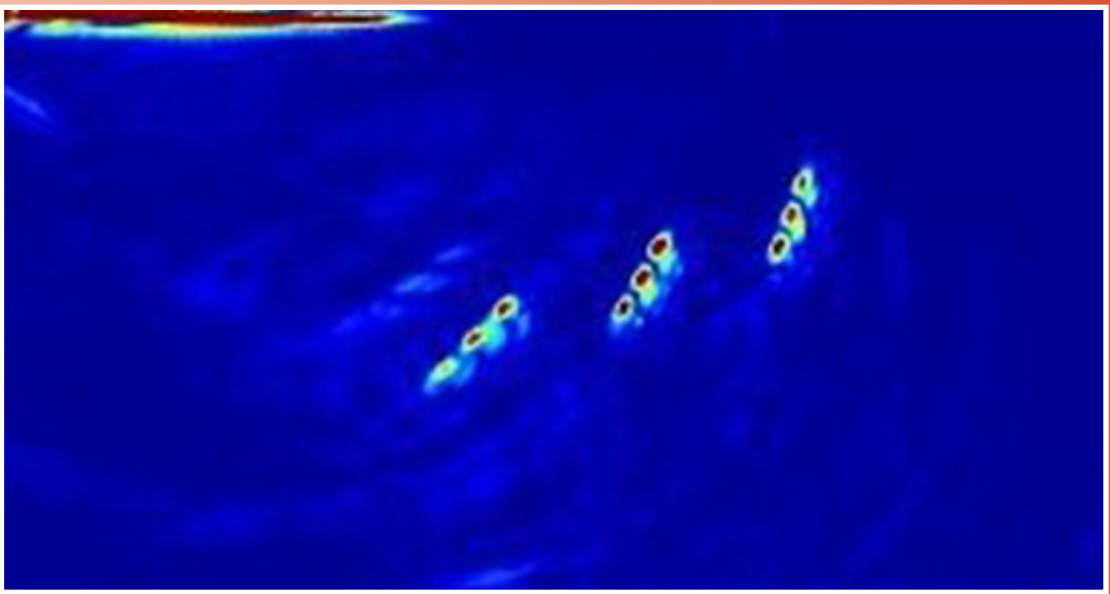
"Access for this amount of scanning is not always possible and thus results cannot be optimized," says Sauser. "Time-of-flight diffraction studies have shown good results except near the scanning surface where detectability is less reliable and where member geometry conflicts with the time-of-flight diffraction scanning equipment."

USACE is currently conducting research on advanced ultrasonic testing methods, PAUT, time-of-flight diffraction, total focusing method, and full matrix capture in order to evaluate these systems for detecting and sizing defects in welded steel joints. The first phase will evaluate the capabilities of the equipment to determine what can reliably be detected with ultrasonic testing.

One of the outcomes of this phase will be guidance on developing test procedures to optimize equipment capabilities and to define the limits of what can be reliably







ABOVE LEFT: Using conventional PAUT methods with an unfocused sound beam–as an inspector would when doing an initial scan for flaws without knowing whether any exist or where they might be located–produces a display like this one. The three sets of holes in the steel block are visible, but are not distinct.

ABOVE RIGHT: Once an inspector discovers flaws using an unfocused sound beam, the scan is repeated using a focused beam. The greater resolution of the image produced provides more information about the number and size of holes in each set.

RIGHT: With advanced full matrix capture PAUT scanning, the display provides enough resolution to clearly show the three sets of three holes in the steel block.

Sources: FHWA.

The welds between steel plates used in fabricating bridge girders can develop flaws both during manufacturing and after construction.

© High Steel.

detected and sized with these methods. The second phase will evaluate the reliability of operators by conducting round-robin testing of flawed samples. The outcome of this phase will be the development of operator qualification requirements, such as performance qualification procedures or other means that increase the reliability of results. The overall outcome of the research will be to quantify the reliability of the system, equipment, and operator and to incorporate that into the evaluation process for fitness for service.

The Bridge Fabricator's Perspective

PAUT offers significant advantages in weld inspection. Compared to radiographic testing, it is far less disruptive in the shop, is much safer, and is better at locating flaws because PAUT provides flaw depth information that radiographic testing does not. Further, it provides inspection at a wide range of angles, improving discovery of planar discontinuities, and, when defects are discovered, it provides more accurate defect location. Compared to ultrasonic testing, PAUT generally takes longer to use, but it is less operator-sensitive, and when encoded, it offers the advantage of providing a permanent record of the data that can be reexamined or verified at any time.

"Each of the three of the volumetric methods in D1.5 presents some advantage over the others, but, on balance, PAUT offers the best overall quality verification," says Ronald Medlock, the vice president for Technical Services at a steel manufacturer. "Given this and its improved safety, PAUT represents a logical and superior replacement for radiographic testing in a steel bridge fabrication shop."

The Future of Advanced Methodologies

All of the major manufacturers of PAUT equipment have systems capable of full matrix capture and total focusing method either already on the market or in the process of development for marketing. That all the major manufacturers have pursued this relatively new system capability is a strong indicator that these methods are the new direction for ultrasonic inspection and parallels how PAUT was developed and implemented. As recently as 5 or 10 years ago, only a few major NDE equipment manufacturers marketed PAUT equipment. Today, there are more than 10 major manufacturers marketing PAUT systems. FHWA expects that full matrix capture and total focusing method will follow the same path. In fact, the capability of full matrix capture and total focusing method systems has emerged much faster than PAUT, with at least five major suppliers already providing the equipment.

FHWA Future Work

FHWA's research plans include the fabrication of additional weld specimens to ensure that researchers can address a more complete test bed of representative flaw types, joint configurations, and plate thicknesses. The new specimen flaw types will be established after getting additional input from bridge owners, fabricators, and other industry stakeholders. The expected weld flaws include longitudinal cracks, transverse hydrogen-related cracks, incomplete fusion, incomplete penetration, slag, and porosity. The vertical fusion faces in electroslag welding narrow gap and electrogas welding processes require special manual pitch-catch type ultrasonic scans when a discontinuity is noted in weld metal-base metal fusion interface. The feasibility of using PAUT techniques to perform these historic manual pitch-catch type scans needs to be developed and evaluated as a potential AWS D1.5 annex requirement.

FHWA will also evaluate advanced ultrasonic flaw modeling software to supplement the ultrasonic validation data. Through modeling, the ultrasonic response from flaws with various types, sizes, lengths, and orientations can be simulated and evaluated according to the AWS D1.5 criteria. Using modeling should limit the number of additional weld specimens that need to be fabricated and inspected. A small set of actual implanted flaws will be manufactured and used to physically validate the modeling and provide additional confidence in the modeling results.

FHWA is also evaluating PAUT full matrix capture, time of-flight diffraction, two-dimensional PAUT arrays, and other advanced ultrasonic testing techniques to evaluate potential improvements in flaw detection and flaw sizing. The current AWS D1.5 manual ultrasonic acceptance criteria require the use of probe motion-based techniques to identify flaws with significant flaw-through-wall height. The use of advanced techniques will support the potential addition of a quantifiable acceptance criterion for this condition. AWS is considering the adoption of new acceptance criteria that use the flaw-through-wall height, as there is a general industry trend toward more of a fitness for service approach to ultrasonic acceptance criteria in lieu of the historic workmanship flaw signal amplitude-based criteria.

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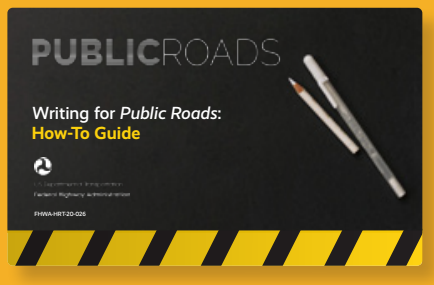

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Rural roadways are critical to the Nation's transportation network.
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Along the Road is the place to look for information about current and upcoming activities, developments, trends, and items of general 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.

Public Information and Information Exchange

USDOT Toolkit Supports Funding Of Rural Transportation Projects

The U.S. Department of Transportation developed an applicant toolkit to provide guidance as part of the Rural Opportunities to Use Transportation for Economic Success (ROUTES) Initiative. This toolkit helps support rural transportation providers in identifying and navigating USDOT discretionary grant funding opportunities. The toolkit provides user-friendly information and resources to support rural applicants' understanding of USDOT discretionary grant programs, planning opportunities, programs, and funding processes.

While one-fifth of Americans live in rural areas, 70 percent of the Nation's road miles are in rural areas, carrying nearly 50 percent of truck traffic. In addition, 44 percent of automobile travel on rural roads is done by metropolitan area citizens and rural traffic fatalities are disproportionately high, with a fatality rate twice that of urban areas. Further, of the Nation's bridges that are posted for weight limits, 90 percent are in rural areas.

The ROUTES Applicant Toolkit illustrates key applicant requirements when participating in the Department's discretionary grants processes. It also catalogues discretionary grant programs by applicant type and eligible project activities. Additionally, the toolkit provides resources for applicants to maximize the potential for award success. The toolkit is available at *www.transportation.gov/rural/toolkit*.

The ROUTES Initiative is coordinated across key modal administrations, including the Federal Highway Administration, the Federal Transit Administration, the Federal Railroad Administration, and the Federal Aviation Administration. For more information, visit *www.transportation.gov/rural*.

USDOT Enhances Safety Band Website

In September 2020, USDOT launched updates to its Safety Band website with new interactive graphics and materials highlighting the importance of the 5.9 gigahertz (GHz) wireless spectrum in addressing State safety challenges across the country.

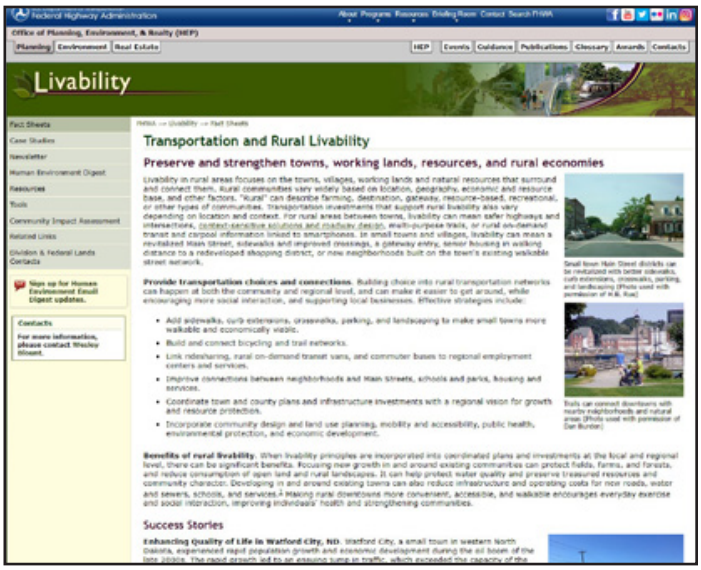
Established by the Federal Communications Commission in 1999, the Safety Band is a dedicated wireless spectrum at 5.9 GHz in use for transportation-related safety communications that enable secure, interoperable, connected, and automated ITS ecosystems.

These technologies use the interference-free Safety Band for high-precision, low-latency vehicle-to-everything (V2X)

communications among vehicles, traffic signals, roadside units, work zones, and even personal devices like smartphones. The technologies generate real-time alerts to prevent crashes, manage traffic flow, warn drivers about hazardous weather conditions, and adjust signals to give emergency vehicles priority in congested traffic. The innovative technologies using the Safety Band have the potential to dramatically improve transportation safety and mobility.

USDOT's enhanced Safety Band site provides detailed information about these lifesaving deployments via an interactive map and a State-by-State index. Users can explore the interactive map to view operational and planned locations across the country deploying V2X communications technologies. The State-by-State index of crash fatalities and related economic costs that could potentially be mitigated through deployment of technology using the Safety Band is available to download.

The Safety Band website also features fact sheets, reports, upcoming related events and announcements, and content from past events on the Safety Band. For more information, visit *www.transportation.gov/content/safety-band*.



Source: FHWA.

FHWA Releases Updated Livability Fact Sheets

FHWA recently released updates to a series of fact sheets discussing how livability considerations during the transportation decisionmaking process can benefit communities. Through the Transportation and Livability resources available at *www.fhwa.dot.gov/livability*, FHWA provides support to State departments of transportation, regional planning agencies, Tribes, and other partners in both rural and urban settings.

The most recent updates focus on the topics of economic development, safety, and rural livability. The "Transportation and Economic Development" fact sheet discusses how targeted transportation investments can improve access to jobs, education, shopping, and goods movement through compact development, relocation decisions, and increased connectivity. "Transportation and Safety" promotes safer roads for all users, including strategies to combine safety and redevelopment, repurpose spaces, and create bike-friendly cities. Since rural communities vary widely, the "Transportation and Rural Livability" fact sheet focuses on providing transportation choices and connections to a broad audience through projects that enhance quality of life, improve safety for students, and create active transportation networks.

All of the livability fact sheets are available at *www.fhwa.dot.gov/livability/fact_sheets*.

The Pennsylvania Department of Transportation's first Safety Citizens challenge asked what teen drivers should know before getting behind the wheel.

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Overhead changeable message signs warn other drivers about wrong-way drivers on the freeway as part of Arizona's pilot project.

© Arizona Department of Transportation.

PennDOT Launches Safety Citizens Program

Pennsylvania Department of Transportation (PennDOT) recently launched its Safety Citizens program, which encourages community members to answer traffic safety questions in original and creative ways.

The program introduces bimonthly traffic safety topics and poses a question for the public to answer. Participants can respond by submitting a short video, a poem, or an original piece of artwork. PennDOT will display selected submissions on statewide social media platforms including Twitter, Facebook, and Instagram.

PennDOT aims to creatively inspire Pennsylvanians to practice safe behaviors on the road. Whether traveling by vehicle, motorcycle, bicycle, or on foot, everyone has the opportunity to be safer on the road. The agency encourages individuals, classes, families, clubs, or other groups to consider this new safety initiative as a program challenge.

The program kicked off in September 2020 with a focus on teen driver safety. PennDOT asked participants to respond to question, "What do you think every teen driver should know before getting behind the wheel?" Some of the featured responses are available at *www.facebook.com/hashtag/safetyCitizens*.

The topic for February 2021 will be highway safety.

For more information, visit *www.PennDOT.gov/SafetyCitizens* or email *SafetyCitizens@pa.gov*.

Technical News

ADOT Innovative System to Detect Wrong-Way Vehicles

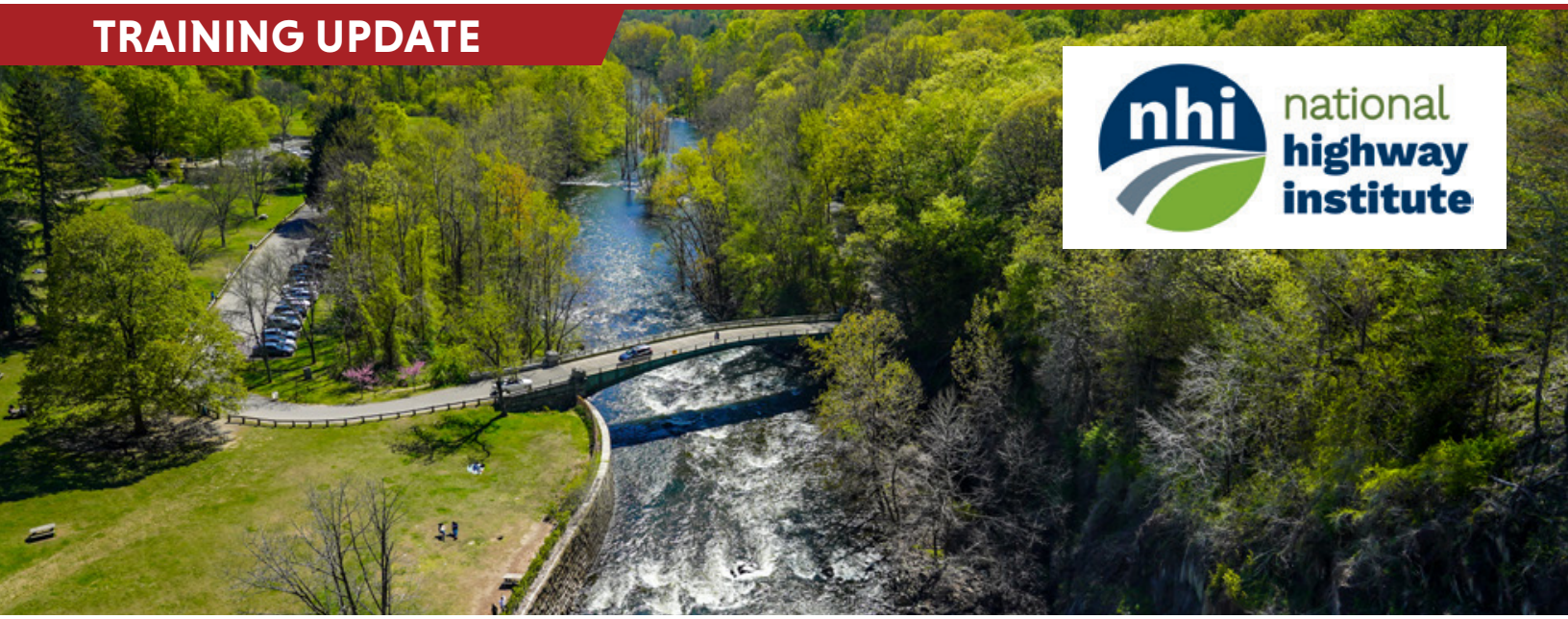
Arizona Department of Transportation (ADOT) is piloting a first-of-its-kind thermal camera system on I–17 in Phoenix to detect wrong-way vehicles. The pilot has proven the technology to be a reliable way to detect wrong-way vehicles, alert law enforcement, and warn other drivers to reduce the risk of crashes involving often-impaired wrong-way drivers. ADOT has already expanded use of the technology, with plans to do more as time and funding allow.

Compared to waiting for 911 calls from other drivers, the immediate alerts provided by thermal camera detections result in faster response times by law enforcement, a finding borne out by ADOT's assessment of the I–17 system. The report assessing the pilot project includes recommendations for ADOT to add components at urban and rural locations as funding becomes available.

ADOT installed the detection technology and converted thermal cameras already used on traffic signals to send alerts to the Traffic Operations Center and the Arizona Department of Public Safety (AZDPS) when wrong-way vehicles are detected. Since the system began operating in January 2018, it has detected more than 100 vehicles traveling the wrong way, mostly on exit ramps and frontage roads.

The alert system also features specialized internally illuminated wrong-way signs with flashing LED lights along I–17 off-ramps, designed to get the attention of a wrong-way driver. At the same time, the system immediately alerts AZDPS and ADOT, enabling law enforcement to respond immediately and ADOT to immediately alert other freeway drivers with "Wrong Way Driver/Ahead/Exit Freeway" warnings on overhead message boards.

In addition to installations completed and planned, ADOT is prepared to work with regional planners on adding wrong-way vehicle alert technology elsewhere as funding becomes available. The priority will be locations with the greatest incidence of wrong-way incursions.



NHI's 2D hydraulic modeling tools course is now available virtually.

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Hydraulic Modeling Training Goes Virtual

by **DR. MELONIE BARRINGTON** and **SABRINA SYLVESTER**

In the past, hydraulic designers and engineers have used one-dimensional modeling tools for bridge and other hydraulic structure projects. Although improvements have been made throughout the years, this modeling tool has caused inaccurate outcomes.

As part of the fourth and fifth rounds of Every Day Counts, the Federal Highway Administration created Collaborative Hydraulics: Advancing to the Next Generation of Engineering (CHANGE) modeling tools to improve the design and communication for a more efficient project delivery.

This two-dimensional (2D) hydraulic modeling resource provides a better understanding of the multifaceted collaboration between waterway environments and transportation assets—therefore resulting in designing safer, more cost-effective, and more resilient structures on waterways.

The benefits of 2D modeling tools include:

- More precise flow condition representation to improve project quality
- Better communication of complex interaction between waterways, transportation infrastructure, and surrounding environments through 3D graphical visualizations
- Improved collaboration to streamline project development

Achieving Success with the National Highway Institute

NHI now offers virtual training of this 2D modeling tool. Designers and engineers can sign up for the Two-Dimensional Hydraulic Modeling of Rivers at Highway Encroachments course (FHWA-NHI-135095). Participants will be introduced to comprehensive 2D modeling concepts, as well as extracting hydraulic parameters for bridge scour evaluation use. In this 3-day course, learners will identify the difference between one-dimensional and 2D hydraulic models; use background and surface water modeling systems to run 2D models projects; and visualize, add, and review structures and 2D models.

The following additional online courses present supplementary trainings to further understand, identify, and use 2D modeling technology to improve projects between transportation infrastructure, waterways, and surrounding environments.

SRH-2D Model Data Files, Diagnostics & Verifying 2D Model Results WCT (FHWA-NHI-135095A). This Web-conference training (WCT) introduces data files used for sedimentation and river hydraulics (SRH) 2D input. Participants will learn how to monitor lines in SRH-2D and how to use their output to verify model convergence.

Model Terrain Development with Various Data Sources WCT (FHWA-NHI-135095B). This WCT provides instruction to identify potential data issues, process and effectively define geometry for 2D hydraulic models, and modify geometry methods for simulation and data sourcing.

Course participants should be familiar with the fundamentals of open channel flow hydraulics before taking any instructor-led hydraulics courses. Consequently, NHI offers a free Web-based training, Basic Hydraulic Principles Review (FHWA-NHI-135091), as a prerequisite refresher course.

How to Attend or Host a Course

NHI invites professionals interested in earning continuing education units or professional development hours to visit *http://bit.ly/NHIHome* and browse the complete digital course catalog, which encompasses more than 400 courses spanning 18 program areas. To sign up for alerts when a course session is scheduled, visit the individual course's description page and select the "Sign Up for Session Alerts" link.

Interested hosts can submit a Host Request Form or find more information about hosting NHI courses by visiting *http://bit.ly/NHIHome*.

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DR. MELONIE BARRINGTON is an NHI training program manager.

SABRINA SYLVESTER is a contracted senior marketing specialist for NHI.

The Local Road Safety Plan Do-It-Yourself site offers a highly visual interface with many videos, downloads, and examples to provide the right information at the right time.

Source: FHWA.

Helping Locals Develop Local Road Safety Plans

by **HILLARY ISEBRANDS** and **JERRY ROCHE**

Approximately 40 percent of the Nation's roadway fatalities occur on locally owned roads—an average of 12,000 deaths each year. Local road safety plans (LRSPs) offer a proven safety countermeasure that can help address the issue. Local agencies can use LRSPs to identify at-risk locations on their roadways and deploy cost-effective safety solutions.

The Federal Highway Administration recently unveiled a unique website to help local agencies reduce serious and fatal crashes on their roadways. The Local Road Safety Plan Do-It-Yourself website (available at *https://safety.fhwa.dot.gov/LRSPDIY*) includes resources that local agencies and their partners need to create and implement these plans in order to save lives.

Expanding FHWA's Reach

FHWA, in cooperation with the National Association of County Engineers and the National Local & Tribal Technical Assistance Program Association, has spent the last 5 years helping local agencies create these plans, but with more than 23,000 local agencies in the country, it is impossible to deliver in-person training to each one. Consequently, FHWA developed the website to connect with all local agencies efficiently.

The LRSP website comprises a delivery method to simulate a personal, hands-on workshop experience to guide agencies through the LRSP development process: identifying stakeholders, using safety data, choosing proven solutions, and implementing solutions.

LRSPs have proven to be successful in small and large agencies alike. The plans all include some common steps, but they are tailored to reflect each community's needs. FHWA's new site explains how. A quote attributed to President Theodore Roosevelt provides inspiration for deploying LRSPs: "Do what you can, with what you have, where you are."

Site Features

Each page has an introduction video in the center that explains the primary objectives of that step. Along the right sidebar there are additional videos, such as Local Agency Insights, which feature practitioners sharing their experiences in developing local road safety plans.

Each page includes a Tools and Resources section with a wealth of information in the form of guides, templates, tools, tutorials, training, examples, and helpful links. The site went live on October 1, 2020, and is being updated periodically with additional content.

"Our goal is to connect FHWA to America's 3,000 counties and 20,000 cities and towns that could benefit from a local road safety plan," says FHWA Administrator Nicole R. Nason. "This innovative new tool includes everything local agencies need to develop a local road safety plan to help reduce fatalities on their local roads."

For more information, contact Hillary Isebrands at *hillary.isebrands@dot.gov* or Jerry Roche at *jerry.roche@dot.gov*.

HILLARY ISEBRANDS, P.E., Ph.D., is a senior safety engineer/team leader on the Safety and Design Technical Service Team in FHWA's Resource Center.

JERRY ROCHE, P.E., is a transportation specialist on the Safety Design Team in FHWA's Office of Safety.

COMMUNICATION PRODUCT UPDATES

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).

Compiled by **LISA A. SHULER** of FHWA's Office of Corporate Research, Technology, and Innovation Management

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

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For more information on R&T communications products available from FHWA, visit FHWA's website at *www.fhwa.dot.gov*, the FHWA Research Library at *www.highways.dot.gov/resources/research-library/federal-highway-administration-research-library* (or email *fhwalibrary@dot.gov*), or the National Transportation Library at *ntl.bts.gov* (or email *library@dot.gov*).

Properties and Behavior of UHPC-Class Materials

Publication Number: FHWA-HRT-18-036

Ultra-high performance concrete (UHPC) is a cementitious composite material composed of an optimized gradation of granular constituents, a water-to-cementitious materials ratio less than 0.25, and a high percentage of discontinuous internal fiber reinforcement. UHPC-class materials can be differentiated from conventional concrete-like materials by their exceptional mechanical and durability properties. As the demand for this innovative class of materials increases, so will the need for knowledge about the material properties and characteristics.

To fill this knowledge gap, researchers at FHWA's Turner-Fairbank Highway Research Center (TFHRC) executed an experimental study on six different commercially available materials being marketed as UHPC class. The goal of the research was to provide the bridge engineering community with a more comprehensive set of properties for this class of materials, which in turn could facilitate broader use within the sector. The researchers evaluated the UHPC-class materials using 14 different test methods developed by ASTM, the American Association of State Highway and Transportation Officials, or the TFHRC. Results indicate that these materials behave similarly with respect to some performance measures such as compressive strength, tensile strength, and durability, but vary with respect to others such as dimensional stability, bond to precast concrete, and compressive creep.

The publication is available at *www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/18036/index.cfm*.

Performance of Grouted Connections for Prefabricated Bridge Deck Elements

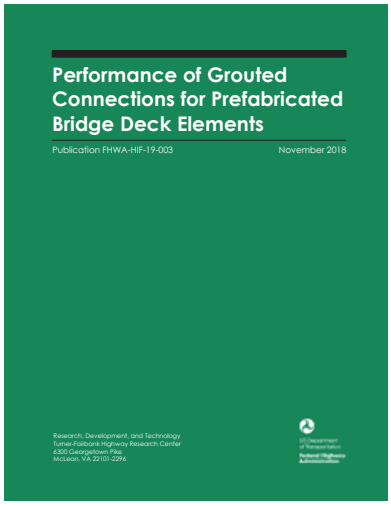
Publication Number: FHWA-HIF-19-003

Accelerated bridge construction (ABC) has become increasingly popular for new bridges and for replacement/rehabilitation projects. ABC offers numerous advantages, which include reduced traffic disruption, expedited project delivery, and increased work zone safety. To realize some of these advantages, construction typically employs prefabricated bridge elements and systems (PBES).

Laboratory research and field studies indicate that the primary challenge for PBES lies in the design and construction of the connections, which are typically made using interlaced connector elements and field-cast grout. Poor detailing and design considerations have been shown to pose problems with fabrications, construction, durability, and capacity.

This study investigated deck-level connections employing interlaced reinforcing bars with different grout materials and different

precast panel details for potential use in accelerated bridge construction projects. The research team began by reviewing relevant literature to determine promising grout materials for field-cast connections as well as different precast panel details currently being deployed in precast deck systems. Researchers then created a test matrix of grout materials and different connection detail combinations.



The research team conducted two series of experiments. The first tested the bond behavior between precast concrete and different connection grouts. The second investigated several parameters frequently considered during the design of these connections: shear key shape, reinforcement type, connection grout material type, and precast surface preparation.

The study concluded that test variables showed varying influence on the behavior of the deck-level connections. Thus, the selection of field-cast grout materials represents one of the most critical design considerations for deck-level PBES connections.

The publication is available at *www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/19003/index.cfm*.

Techbrief: Safety Evaluation of Flashing Yellow Arrows at Signalized Intersections

Publication Number: FHWA-HRT-19-035

A flashing yellow arrow for permissive left-turn movements at signalized intersections helps drivers who are turning left on a permissive circular green signal avoid confusion. The concern is that drivers turning left on a permissive circular green signal might mistake that signal as implying that the left turn has the right-of-way over opposing traffic, especially under certain geometric conditions.

FHWA's study aimed to undertake a before-and-after evaluation of the safety effectiveness of flashing yellow arrows at signalized intersections. The study used data from four States—Nevada, North Carolina, Oklahoma, and Oregon—to examine the effects for specific crash types, including total, injury and fatal, rear-end, angle, left-turn, and left-turn opposite through crashes. The evaluation included 307 treated sites and 438 reference sites.


TECHBRIEF

Safety Evaluation of Flashing Yellow Arrows at Signalized Intersections

FHWA Publication No.: FHWA-HRT-19-035

FHWA Contact: Roya Amjadi, HRDS-20, ORCID: 0000-0001-7672-8485, (202) 493-3383, roya.amjadi@dot.gov

This document is a technical summary of the Federal Highway Administration report *Safety Evaluation of Flashing Yellow Arrows at Signalized Intersections* (FHWA-HRT-19-036).[1]

OBJECTIVE

The Federal Highway Administration (FHWA) established the Development of Crash Modification Factors (DCMF) Program in 2012 to address highway safety research needs for evaluating new and innovative safety strategies (improvements) by developing reliable quantitative estimates of their effectiveness at reducing crashes. The ultimate goal of the DCMF Program is to save lives by identifying new safety strategies that effectively reduce crashes and promoting those strategies for nationwide implementation by providing measures of their safety effectiveness and benefit–cost (B/C) ratios through research. State transportation departments and other transportation agencies need to have objective measures for safety effectiveness and B/C ratios before investing in broad applications of new strategies for safety improvements. Forty State transportation departments provided technical feedback on safety improvements to the DCMF Program and implemented new safety improvements to facilitate evaluations. These States are members of the Evaluation of Low-Cost Safety Improvements Pooled Fund Study, which functions under the DCMF Program.

This study investigated the safety effectiveness of the flashing yellow arrow (FYA) treatment at signalized intersections. One objective of this strategy was to reduce the frequency of left-turn (LT) crashes, especially those that involve a collision between left turns and vehicles traveling straight through from the opposite direction (also called left-turn opposite through (LTOT) crashes). Many studies have explored the safety effectiveness of FYAs. However, most of them only used data from one State, and the studies that used data from multiple States had limited samples of intersections.[2] It is clear that an evaluation with a large sample of sites from multiple States would provide useful information to practitioners on the effectiveness of this treatment under different circumstances.

INTRODUCTION

An FYA for permissive left-turn movements at signalized intersections helps drivers who are turning left on a permissive circular green signal avoid confusion. The concern is that drivers turning left on a permissive circular green signal might mistake that signal as implying that the left turn has the right-of-way over opposing traffic, especially under some geometric conditions.

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
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https://highways.dot.gov/research

The research found that a flashing yellow arrow is the best overall alternative to the circular green signal as the permissive signal display for a left-turn movement and that left-turn drivers demonstrated a high level of understanding and correct response to flashing yellow arrows. Also, a flashing yellow arrow display in a separate signal face for the left-turn movement offers more versatility in field application. It is capable of operating in any of the various modes of left-turn time-of-day operations and is easy to program to avoid the "yellow trap" associated with some permissive turns at the end of the circular green signal.

The results of this study show that crashes decrease when flashing yellow arrow signal phasing replaces a permissive or protected/permitted left-turn signal. The crash reduction ranged from 15 to 50 percent depending on the treatment type. The treatment has a positive benefit, especially for total crashes, injury and fatal crashes, and crashes related to left-turn movements.

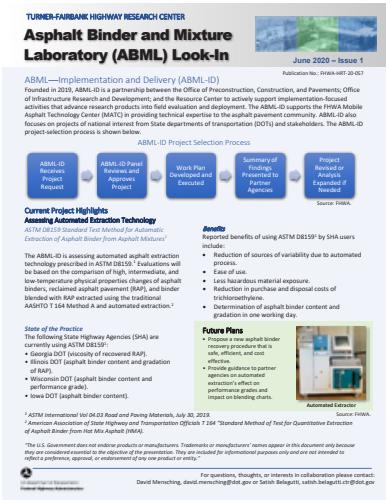
The publication is available at *www.fhwa.dot.gov/publications/research/safety/19035/index.cfm*.

Asphalt Binder and Mixture Laboratory (ABML) Look-In

Publication Number: FHWA-HRT-20-057

The Asphalt Binder and Mixture Laboratory–Implementation and Delivery (ABML-ID) is currently assessing automated asphalt extraction technology prescribed in ASTM D8159, the Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures. Evaluations will be based on the comparison of physical property changes in high, intermediate, and low-temperature asphalt binders, reclaimed asphalt pavement (RAP), and binder blended with RAP extracted using the traditional AASHTO T 164 Method A and automated extraction.

ASTM D8159 covers the quantitative determination of asphalt binder content in asphalt mixtures and pavement specimens—using the automated computer controller or human-machine interface system—to perform a solvent extraction for specification acceptance, service evaluation, quality control, and research. The benefits of ASTM D8159 include the reduction of sources of variability due to automated process, ease of use, less hazardous material exposure, reduction in purchase and disposal costs of trichloroethylene, and determination of asphalt binder content and gradation in one working day.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Asphalt Binder and Mixture Laboratory (ABML) Look-In

June 2020 – Issue 1

Publication No.: FHWA-HRT-20-057

ABML—Implementation and Delivery (ABML-ID)

Founded in 2019, ABML-ID is a partnership between the Office of Preconstruction, Construction, and Pavements; Office of Infrastructure Research and Development; and the Resource Center to actively support implementation-focused activities that advance research products into field evaluation and deployment. The ABML-ID supports the FHWA Mobile Asphalt Technology Center (MATC) in providing technical expertise to the asphalt pavement community. ABML-ID also focuses on projects of national interest from State departments of transportation (DOTs) and stakeholders. The ABML-ID project-selection process is shown below.

ABML-ID Project Selection Process

ABML-ID Receives Project Request → ABML-ID Panel Reviews and Approves Project → Work Plan Developed and Executed → Summary of Findings Presented to Partner Agencies → Project Revised or Analysis Expanded if Needed

Source: FHWA.

Current Project Highlights

Assessing Automated Extraction Technology

ASTM D8159 Standard Test Method for Automatic Extraction of Asphalt Binder from Asphalt Mixtures[1]

The ABML-ID is assessing automated asphalt extraction technology prescribed in ASTM D8159.[1] Evaluations will be based on the comparison of high, intermediate, and low-temperature physical properties changes of asphalt binders, reclaimed asphalt pavement (RAP), and binder blended with RAP extracted using the traditional AASHTO T 164 Method A and automated extraction.[2]

State of the Practice

The following State Highway Agencies (SHA) are currently using ASTM D8159[1]:

- Georgia DOT (viscosity of recovered RAP).
- Illinois DOT (asphalt binder content and gradation of RAP).
- Wisconsin DOT (asphalt binder content and performance grade).
- Iowa DOT (asphalt binder content).

Benefits

Reported benefits of using ASTM D8159[1] by SHA users include:

- Reduction of sources of variability due to automated process.
- Ease of use.
- Less hazardous material exposure.
- Reduction in purchase and disposal costs of trichloroethylene.
- Determination of asphalt binder content and gradation in one working day.

Future Plans

- Propose a new asphalt binder recovery procedure that is safe, efficient, and cost effective.
- Provide guidance to partner agencies on automated extraction's effect on performance grades and impact on blending charts.

Automated Extractor

Source: FHWA.

[1] *ASTM International Vol 04.03 Road and Paving Materials, July 30, 2019.*

[2] *American Association of State Highway and Transportation Officials T 164 "Standard Method of Test for Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA).*

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For questions, thoughts, or interests in collaboration please contact: David Mensching, david.mensching@dot.gov or Satish Belagutti, satish.belagutti.ctr@dot.gov

ABML-ID is a partnership between the Office of Preconstruction, Construction, and Pavements; the Office of Infrastructure Research and Development; and the Resource Center to actively support implementation-focused activities that advance research products into field evaluation and deployment. The ABML-ID supports the FHWA Mobile Asphalt Technology Center in providing technical expertise to the asphalt pavement community. ABML-ID also focuses on projects of national interest from State departments of transportation and stakeholders.

The publication is available at *www.fhwa.dot.gov/publications/research/infrastructure/pavements/20057/index.cfm*.

High Friction Surface Treatment (HFST) Quick Reference

High Friction Surface Treatment (HFST) is a pavement surface treatment consisting of a polymer resin binder used to bond a 1- to 3-millimeter nominal-size polish- and abrasion-resistant aggregate to the pavement surface. HFST is typically used as a spot treatment on targeted locations, and specifically restores or enhances the friction of virtually any structurally sound pavement surface to reduce roadway departure crashes.

This quick reference guide provides an overview of HFST including applications, site selection, specifications, materials, installation, inspection, testing and acceptance, and performance monitoring. It also provides links to additional resources for more information.

The publication is available at *www.fhwa.dot.gov/publications/research/safety/highfriction/index.cfm*.

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