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Autumn 2020

Wildlife Crossing

Wyoming has been addressing conflicts between wildlife and vehicles on highways for decades.

U.S. Department of Transportation
Federal Highway Administration

Also in this issue:

PUBLICROADS
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FEATURES

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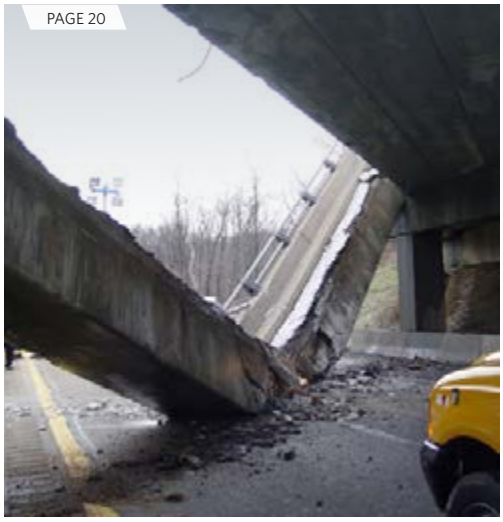

Source: FHWA.

DEPARTMENTS

COVERS and ABOVE—Bison, Wyoming's State mammal, and other wildlife such as deer, bear, and elk, often come into contact with vehicles on both rural and urban roadways. Wyoming Department of Transportation has been addressing the issue for many years, and continues to find news ways to reduce collisions and strengthen safety measures. See "Improving Safety for Travelers and Wildlife" on page 9 of this issue of *Public Roads*.

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Car interior: © metamorworks / iStock.com.

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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).

Creative Solutions to Today's Challenges

By any measure, 2020 tested our Nation. As if the global health crisis associated with the coronavirus wasn't bad enough, the Nation also suffered from hurricanes in the South, wildfires throughout the West, and a derecho that devastated much of Iowa.

The unprecedented challenges we all faced this year forced everyone to manage circumstances we've never had to contemplate before, such as having most of our workforce teleworking. Despite the majority of Federal Highway Administration employees teleworking, agency staff across the Nation continued working hard to support our State, local, Tribal, and other Federal partners to deliver the Federal-aid highway program.

First, with each State adapting different approaches in response to the emergency to protect communities and employees, there was an immediate need to support public awareness. FHWA's division offices closely coordinated with State and local highway agencies regarding their authority to use changeable message signs for messages concerning COVID-19 during the Presidentially declared national emergency.

Next, the national health emergency brought with it increased demand for delivery of critical medical supplies and other essential goods necessary for communities to respond to the pandemic. In response to the increased demand on freight, FHWA worked with Congress to ensure that States had the authority to issue permits for overweight vehicles and loads.

Similarly, we worked with the American Association of State Highway and Transportation Officials and State transportation partners around the country to keep the National Network open in order to facilitate the safe, efficient, and seamless transport of critical supplies across the Nation.

Then, we found new ways to serve the freight community, such as by empowering States to temporarily allow food trucks to sell meals to truck drivers in rest areas near the highway. Despite the fact that commercial activity at rest areas has long been prohibited, we coordinated closely with States on this creative solution to use enforcement discretion to be sure America's truckers had access to food services while they were on the job working to deliver critical relief supplies to our communities. Unique challenges require unique solutions. Due to closed restaurants nationwide, our actions helped keep truck drivers safe, and kept the deliveries of thousands of products—including ventilators, medicines, medical testing equipment, and masks—arriving on schedule.

FHWA also worked with States to permit the temporary use of sidewalks and parking areas in highway rights-of-way for additional restaurant seating or other retail space. Outside the box thinking helped countless small businesses and supported the Nation's economic recovery.

Finding new ways to solve new problems was a priority for us throughout the year. The spirit of cooperation for which FHWA is known made this easier, which makes this issue of *Public Roads* seem so relevant. We have been pioneering creative new solutions to a host of problems for years, and this issue shines a light on some of the most interesting.

As I've said many times, transportation is a team sport. Perhaps now more than ever, our continued coordination and collaboration will be critical to our success in delivering our transportation programs and keeping America moving.

Nicole R. Nason
Administrator
Federal Highway Administration

The AAS degree program in highway maintenance management can help prepare transportation professionals for advancement in their organizations.

Celebrating the Anniversary of the Highway Maintenance Management AAS Degree Program

by **GAY DUGAN** and **SABRINA SYLVESTER**

Approximately 1 year ago, the first-ever degree program in the Nation for highway maintenance management opened for enrollment. Highway maintenance is essential to ensure the safety of U.S. roads, bridges, and highways, and therefore developing the Nation's highway maintenance workforce is critical. Understanding this need, the National Highway Institute (NHI), the Colorado Department of Transportation, Front Range Community College (FRCC), the Colorado Local Technical Assistance Program (LTAP), the Colorado chapter of the American Public Works Association, county agencies, and municipal public works departments all collaborated to make a degree program a reality.

The associate of applied science (AAS) degree in highway maintenance management at FRCC is a 2-year program that prepares highway maintenance professionals for advancement in managerial positions within their respective organizations. The curriculum is offered online, making it more accessible for students employed by State and local agencies across the country to pursue professional development in this field.

The program benefits highway maintenance employees looking for advancement in government agencies at the Federal, State, and local levels, as well as private sector organizations. Learners develop leadership skills including budgeting, project management, employee supervision, communications, and team building. The curriculum enables students to hone technical skills in maintenance and operations including highway safety, bridge maintenance, traffic operations, environmental protection, and emergency and incidental management.

Select NHI trainings in the asset management, construction and maintenance, and pavement and materials program areas are incorporated into the curriculum. These include one of NHI's premier training courses, the NHI-134063 Maintenance Leadership Academy. In addition, FRCC's prior learning assessment process enables students to receive college credit for their current industry experience, skillset, training, and certifications in their current jobs in highway maintenance.

According to Susan Baillargeon, FRCC's highway maintenance management program director, "the biggest appeal is to receive college credit for the knowledge they've been learning on the job." Students can transcribe their training with industry providers, including NHI and LTAP, to receive credit toward their degree.

The partnership between FRCC and industry organizations serves as a model for other States to create their own highway maintenance training program. There are already efforts within the educational community to work with States to establish accredited apprentice programs and foster interest in establishing similar programs in high schools, community colleges, and universities in other parts of the country. These efforts build on each other to support the workforce needs of the transportation industry and help increase diversity.

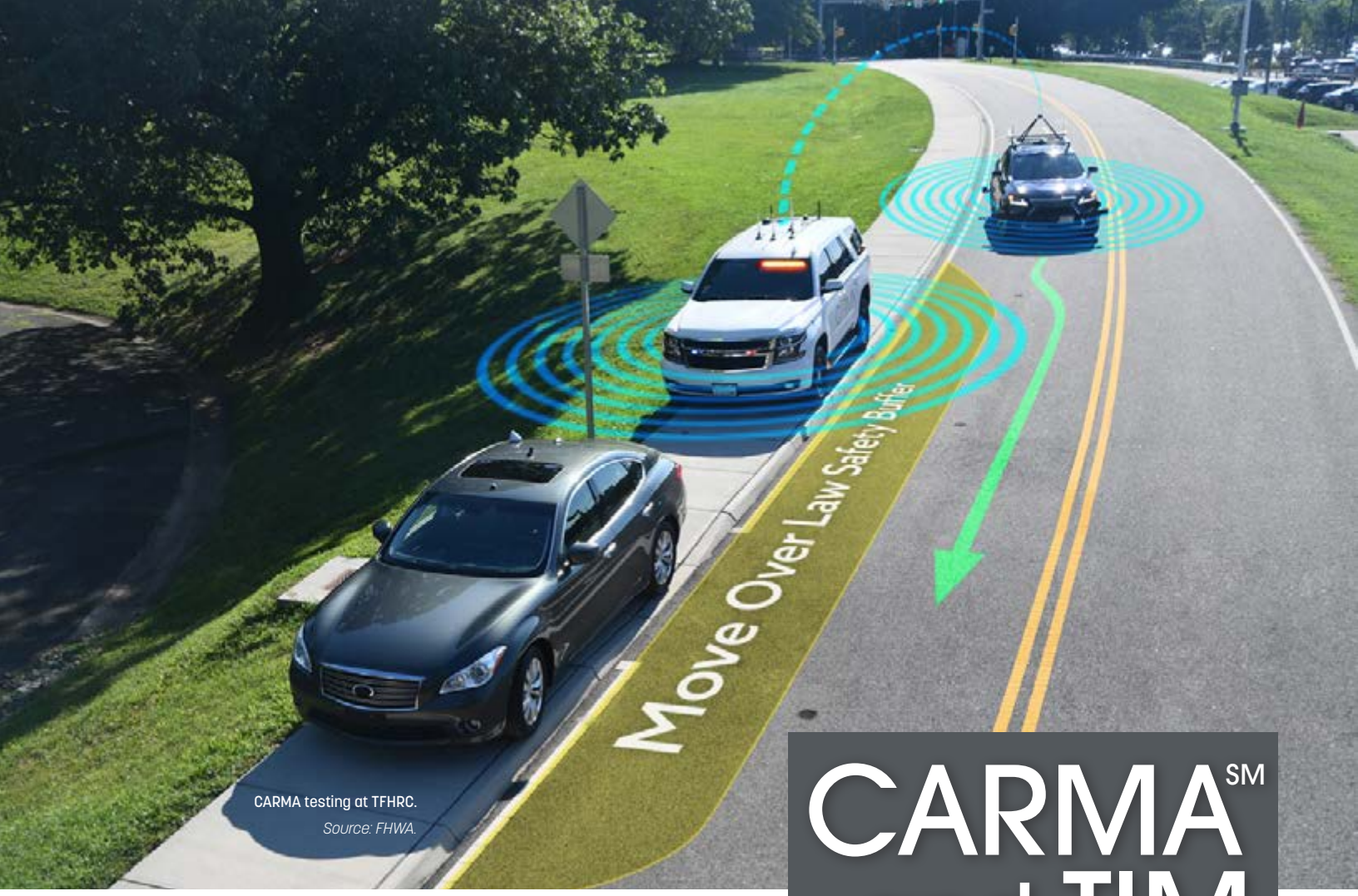
Also in its introductory year, the program was the recipient of the 2019 League of Excellence Award for the State of Colorado from the League for Innovation in the Community College, the only community college in the State to receive this award.

FRCC launched this award-winning AAS degree program in the fall of 2019, and about 35 students have completed the program thus far. "I'd love to see another 22 to 30 students this fall," says Baillargeon.

NHI continues to collaborate with industry professionals and organizations to ensure that its constituents receive quality highway transportation training that supports a performance-based culture and strategic, measurable approaches to manage resources to improve the conditions and safety of the Nation's roads, highways, and bridges—one course at a time, one program at a time.

To learn more about FRCC's highway maintenance management AAS degree program, visit *http://bit.ly/PRHotTop_Aut2020*. To learn more about NHI trainings, visit *www.nhi.fhwa.dot.gov*.

GAY DUGAN is a training program manager at NHI.
SABRINA SYLVESTER is a contractor at NHI.



CARMA testing at TFHRC.
Source: FHWA.

CARMA℠ and TIM

FHWA's CARMA Program supports many transportation systems management and operations use cases, including TIM scenarios.

The CARMA Program is spearheading research on cooperation driving automation (CDA) concepts poised to transform transportation system performance. Traffic incident management (TIM) is a planned and coordinated multidisciplinary process to detect, respond to, and clear traffic incidents so traffic flow can be restored as safely and quickly as possible.

CARMA researchers are identifying TIM scenarios that provide new strategies and improvements for first responder use cases that interact with automated driving systems. One example is the Move Over law, which states vehicles should move out of the lane adjacent to stationary emergency vehicles with flashing lights. The CARMA-equipped passenger vehicle safely enters the opposite lane to provide sufficient space to create a safety buffer for the first responder, ensuring that the officer is not hit by the moving passenger vehicle.

CARMA℠

FHWA will conduct validation testing for selected TIM use case scenarios in early 2021. For more information, visit ***https://highways.dot.gov/research/research-programs/operations/CARMA*** or contact Taylor Lochrane at ***Taylor.Lochrane@dot.gov***.

Putting the Brakes on HUMAN TRAFFICKING

Human trafficking affects more of us than you may think.

Nearly 25 million people are victims of human trafficking globally. The Nation's roadways, airways, and waterways are being used to facilitate the trafficking of human beings.

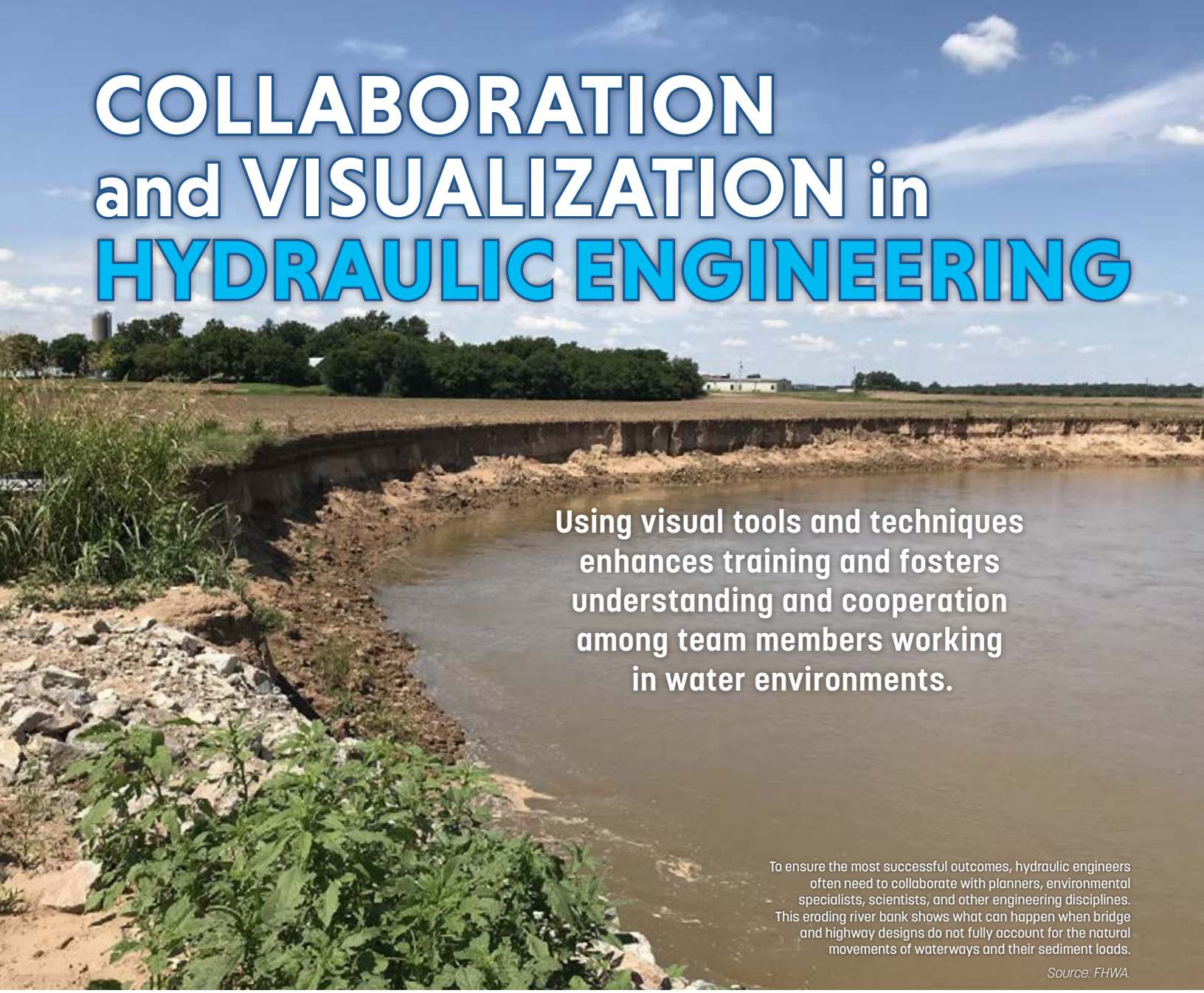
The U.S. Department of Transportation is committed to working with Federal and transportation partners to detect, deter, and disrupt human trafficking across all modes of transportation.

The Department's Advisory Committee on Human Trafficking published a final report in July 2019. In addition, USDOT launched the Transportation Leaders Against Human Trafficking initiative. On January 28, 2020, Transportation Secretary Elaine L. Chao hosted a "100 Pledges in 100 Days" event and called for transportation leaders to sign a pledge against human trafficking.

Learn more about these and other efforts by the Department and the transportation industry in the Winter 2021 issue of *Public Roads*.

For more information, contact *Jihan.Noizet@dot.gov* or *Shari.Schaftlein@dot.gov*, or visit *www.transportation.gov/TLAHT* for strategies, training resources, public awareness materials, and more.

COLLABORATION and VISUALIZATION in HYDRAULIC ENGINEERING



Using visual tools and techniques enhances training and fosters understanding and cooperation among team members working in water environments.

To ensure the most successful outcomes, hydraulic engineers often need to collaborate with planners, environmental specialists, scientists, and other engineering disciplines. This eroding river bank shows what can happen when bridge and highway designs do not fully account for the natural movements of waterways and their sediment loads.

Source: FHWA.

by **ERIC R. BROWN, LAURA GIRARD,** and **KORNEL KERENYI**

Hydraulic engineers work toward safe, economical, and environmentally sensitive transportation solutions wherever precipitation, runoff, streamflow, and ocean waters interact with roads, bridges, and culverts. One specific aspect of hydraulic engineering involves the design of infrastructure in river and stream environments.

The Federal Highway Administration promotes the use of sound river science and engineering principles in the design of river and stream crossings and other infrastructure encroachments on waterways. Collaboration with planners, environmental specialists, scientists, and other engineering disciplines enables hydraulic engineers to consider appropriate ranges of flow depths, velocities, durations, and other parameters for successful design outcomes.

A holistic design of transportation infrastructure in and around waterways requires careful consideration of river and stream processes. An interdisciplinary team approach to project planning, design, and operation that considers these natural processes may result in a successful project.

Structures such as bridges and culverts that do not account for the natural movements of waterways, the sediment and wood material they carry, and the aquatic and terrestrial organisms that call them home may fail to meet multiple design objectives. Factoring in river processes during transportation project development may prevent a river from eroding its riverbanks due to human-induced causes, claiming adjacent land in the floodplain, and jeopardizing transportation infrastructure and other assets.

In circumstances such as these, river flows can also carry and deposit eroded soil from the riverbanks, which could wash over and cover in-stream fish habitats, silt in other bridges and culverts, or pollute lakes and reservoirs. The altered river channel and flow may then expose and erode downstream bridge foundations and approach roadways. When these effects occur, jurisdictions may have to undertake substantial and costly maintenance actions to stabilize the river section and protect the adjacent transportation and agricultural assets.

Unfortunately, transportation agencies frequently face situations like these. A team

An eroding river bank can cause damage downstream to bridges and road crossings.
Source: FHWA.

of interdisciplinary and interagency professionals with knowledge of and experience in river science and engineering can help address these types of planning, design, and maintenance challenges.

Historical Obstacles to Learning And Collaboration

Many transportation agencies do not have the expertise, tools, and confidence to incorporate and apply river engineering and river science concepts to their transportation projects. To an extent, historical methods and tools used to train students and professionals account for the lack of a properly trained workforce.

FHWA hydraulic engineers have received significant feedback from State and local transportation professionals on how technology and training relating to river processes are deployed. Common criticisms of traditional training methods include:

- Training and tools are too technical and "in the weeds" for transportation professionals who do not have extensive experience and education in hydraulic engineering.
- Techniques and methods seem overwhelming and intimidating.
- River and stream assessments require a large amount of data collection and field observations, but agencies lack a practical and established way to organize and use the data for project development and design.
- Concepts and methods are not always intuitive, visual, and understandable.

In the past, engineers, scientists, and many educators have not routinely emphasized the importance of delivering river science and engineering training in an accessible, understandable, and practical form suited to a wide-ranging audience. A well-traveled story within the fields of hydraulic engineering and river science involves Albert Einstein and his son Hans. When Hans told his father he wished to study sediment transport and similar topics in rivers, Einstein is said to have expressed amazement that his son would want to pursue such a complex endeavor! Hans went on to become a pioneer in the fields of river science and sediment transport.

FHWA, like many other agencies and institutions, has historically trained professionals in river engineering and science in a manner that mirrored Einstein's reply to his son. Technical resource documents and training catered to a niche audience of hydraulic engineers and were laden with complex equations, charts, methods, and explanations. For most others who would benefit from at least some of this background knowledge, such as planners, environmental scientists, designers, engineers, and construction and maintenance staff, this material was often thought to be too complex and unattainable to learn.

Because hydraulic engineers and designers collaborate with numerous project stakeholders, successful and expressive communication, a common vocabulary, and a base-level of knowledge are key to project success. Hydraulic engineers, designers, and other project partners routinely experience misunderstandings and frustration when relating concepts and design information in ways that do not incorporate visual context and descriptions. Although river science and hydraulic engineering can be technically challenging fields, key concepts can be easily visualized and demonstrated regardless of the background and experience of the people studying and working in these areas.

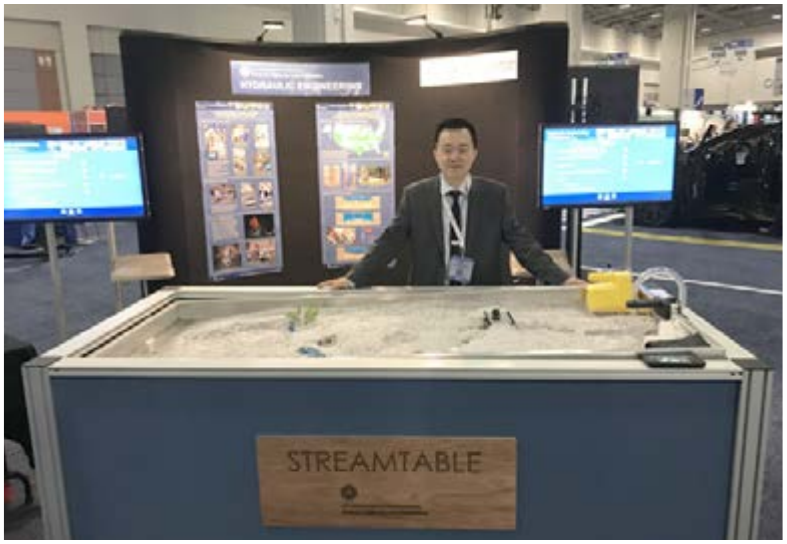
Vermont Focuses on Hands-on Training

River processes, science, and engineering may become intuitive and relatable when practitioners are able to successfully visualize concepts and processes. This insight has led to the success of the Vermont Rivers and Roads Training Program, a collaboration between the Vermont Agencies of Transportation and Natural Resources.

Staci Pomeroy is a river resource scientist with the Vermont Department of Environmental Conservation, Watershed Management Division. As a co-developer of and a lead instructor for the program, she recognizes the value of hands-on-training and stream visits to teach seemingly complex concepts to transportation professionals who have little formal knowledge of river processes.

"There is a saying 'Tell me and I'll forget, but show me and I'll remember,'" says Pomeroy. "This has been a common theme heard from folks attending the Vermont Rivers and Roads Tier 2 Training Program. Now after 8 years of hosting the training, the comments from almost 600 attendees have indicated the importance of hands-on training. The success of the Rivers and Roads training has been to recognize that learning happens in different ways for different people and that providing a

mix of classroom, stream table, and field exercises garners the best chance of someone not only hearing the information but remembering it."



Chao Huang, a contractor with FHWA's J. Sterling Jones Hydraulics Research Laboratory at the Turner-Fairbank Highway Research Center, stands beside a stream table demonstration at the Transportation Research Board Annual Meeting in January 2020.

Source: FHWA.

Rivers and Roads Connection Program

FHWA is following Vermont's lead by developing the Rivers and Roads (R&R) Connection Program to develop and deploy visually engaging, intuitive training and techniques to a broad spectrum of transportation and resource agency professionals that work on projects within river and stream environments. R&R Connection will exemplify how transportation projects in river environments can successfully meet multiple design objectives including public safety, preservation and enhancement of natural ecosystem functions, and resilience. The program will emphasize the importance of clear communication and collaboration among all project partners and stakeholders.

With this program, FHWA aims to increase interest and excitement in natural sciences and engineering by changing the paradigm of training and technology deployment. The new style is intended to be fun, engaging, understandable, practical, and empowering.

Rivers and Roads Program

Attendee comments from Vermont's program indicate the success of hands-on and visual learning methods.

"I enjoyed the excellent mix of class, river flow tables, and field visits."

"The hands-on portion of the class really solidified what was learned in the classroom."

"The mixed-training format has provided a better understanding of river mechanics relative to in-stream work on construction projects."

"The afternoon field trips really brought home the message from morning class and stream table presentations, and now I have a better understanding of what to do after the next flood hits Vermont."

Visualization Tools for Hydraulics

Visualization and hands-on demonstration tools can make complex science and engineering concepts much more accessible.

Taking a cue directly from the Vermont program, FHWA's R&R Connection Program incorporates a stream table. A stream table with a portable flume, plastic sand media, and flowing water can demonstrate how rivers and roads interact in both beneficial and counterproductive ways. For example, FHWA staff use the stream table to present the importance of proper structure location and selection. Improper structure location and selection can exacerbate erosion at structure foundations, trigger river instability, jeopardize motorists, and destroy natural ecosystem features and functions. FHWA intends to make live stream table demonstrations and exercises a core component of an in-development stream dynamics workshop.

FHWA recently completed a second visually engaging and practical tool: a series of field scoping videos. The videos are intended to introduce good practices and procedures of project scoping (such as visual field assessment, data collection, and data interpretation) necessary for the hydraulic design and maintenance of transportation infrastructure. The videos are publicly available on the FHWA YouTube™ channel (*https://www.youtube.com/playlist?list=PL5_sm9g9d4T1YwhKoJZGu3OxhcqqHCLCy*) and target an audience of civil engineers, roadway designers, project managers, and other professionals involved with transportation project planning, development, and design. The specific field scoping video topics cover bridges, river and stream channels, highway drainage (culverts, ditches, medians, pavements, and storm drains), drainage maintenance projects, and pre-field visit data collection.

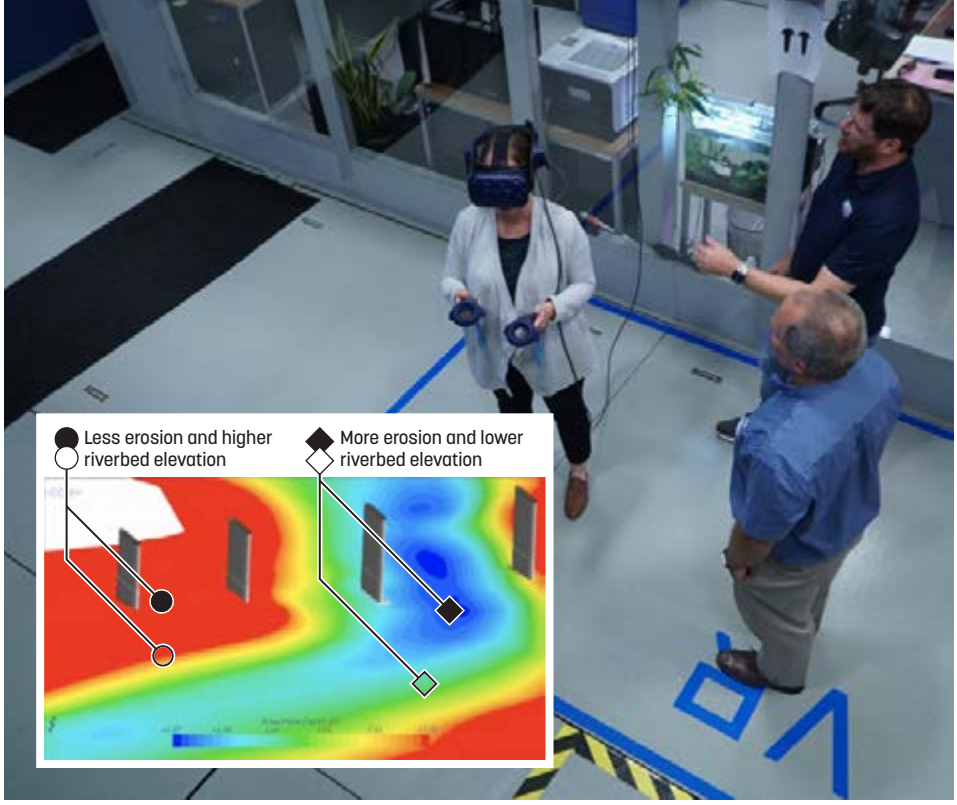
A consultant discusses field scoping practices for bridge projects in FHWA's series of videos.

Source: FHWA.

Theodore Bender, a stormwater hydraulic engineer for the city of Fort Collins, CO, served on the oversight panel for the video project. "In my experience, collaboration has been an essential part of hydraulic engineering and river science," Bender says. "From the first site visit to the last peer review, input from the various interdisciplinary stakeholders creates a robust project that will serve the public for many years to come."

Successfully visualizing flow patterns in rivers and streams can also be accomplished using advanced technology, especially because physical site visits with experts are not always practical. Virtual reality site visits and river assessments will be another component of an FHWA-developed stream dynamics workshop.

FHWA hydraulic engineers have used virtual reality technology to demonstrate how water depths, velocities, and riverbed elevations vary in river channels and around bridge piers and other foundation types. In modeling images, cool colors (blues and greens) are often used to denote deeper or slower moving water and lower channel elevations, and warmer colors (yellows and reds) may denote shallower and faster moving water and higher riverbed and



Virtual reality technology, like the headset used here, can demonstrate how flow may erode a riverbed when moving through a bridge crossing a river. The insert in the lower left shows the heat map display, indicating less erosion and higher riverbed elevations (open/filled circles) along the edges and more erosion and lower riverbed elevations (open/filled diamonds) in the center of the river.

Source: FHWA.

floodplain elevations. FHWA will adapt this technology to perform virtual site visits. The images appearing in the virtual reality display will enable users to see real physical settings including river and stream channels, infrastructure, and their interactions.

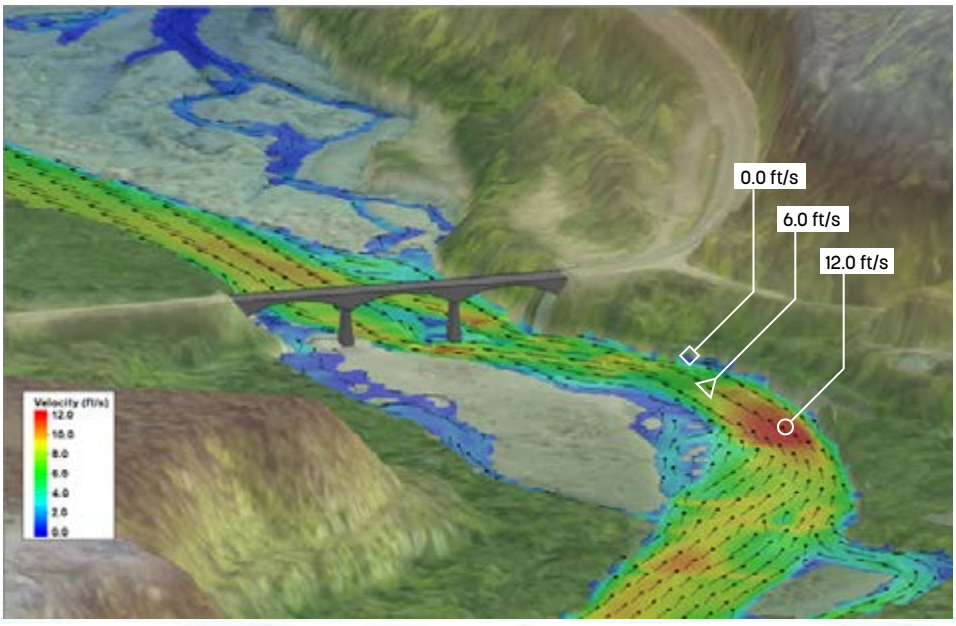
FHWA hydraulic engineers have used an initiative in Every Day Counts round 5 (EDC-5), Collaborative Hydraulics: Advancing to the Next Generation of Engineering (CHANGE), to illustrate how hydraulic modeling software generates visually rich and descriptive results. These modeling results help project design teams convey to stakeholders where the water is flowing and how deep and fast it is moving. Hydraulic models are used to predict flood limits and flow velocities through bridge openings. Water surface elevations can determine the elevations of bridge decks, and flow velocities through the bridges can help determine the necessary depths of foundations.

Computer models can analyze and communicate complex flow patterns in an easily understood manner in which flow arrows show direction throughout the modeled river channel and colors convey faster or slower velocities. The visually descriptive model results enhance communication and reduce misunderstandings and miscommunications between project team members.

"I believe [transportation agencies] are welcoming the quality graphical output from 2D models to enhance collaboration and engage stakeholders," says Scott Hogan, the CHANGE technical lead and a senior hydraulic engineer with the FHWA Resource Center.

Visualization and Collaboration For Success

Flow visualization tools such as stream tables, videos, virtual reality river and stream visits, and hydraulic modeling software are just some of the resources FHWA hydraulic engineers can use to create engaging, fun, and effective learning experiences. FHWA initiatives and State-sponsored efforts such as the Vermont Rivers and Roads Program that visualize water and infrastructure interactions have the potential to profoundly impact current and future generations of transportation professionals, project stakeholders, and educators and students with interest in natural sciences and engineering. Visual and engaging techniques can empower decisionmakers and practitioners with knowledge and skills to effectively preserve or enhance our river and road corridors.



Hydraulic models, such as those deployed in the EDC-5 CHANGE initiative, show water depth, direction, and speed of flow.

Source: FHWA.

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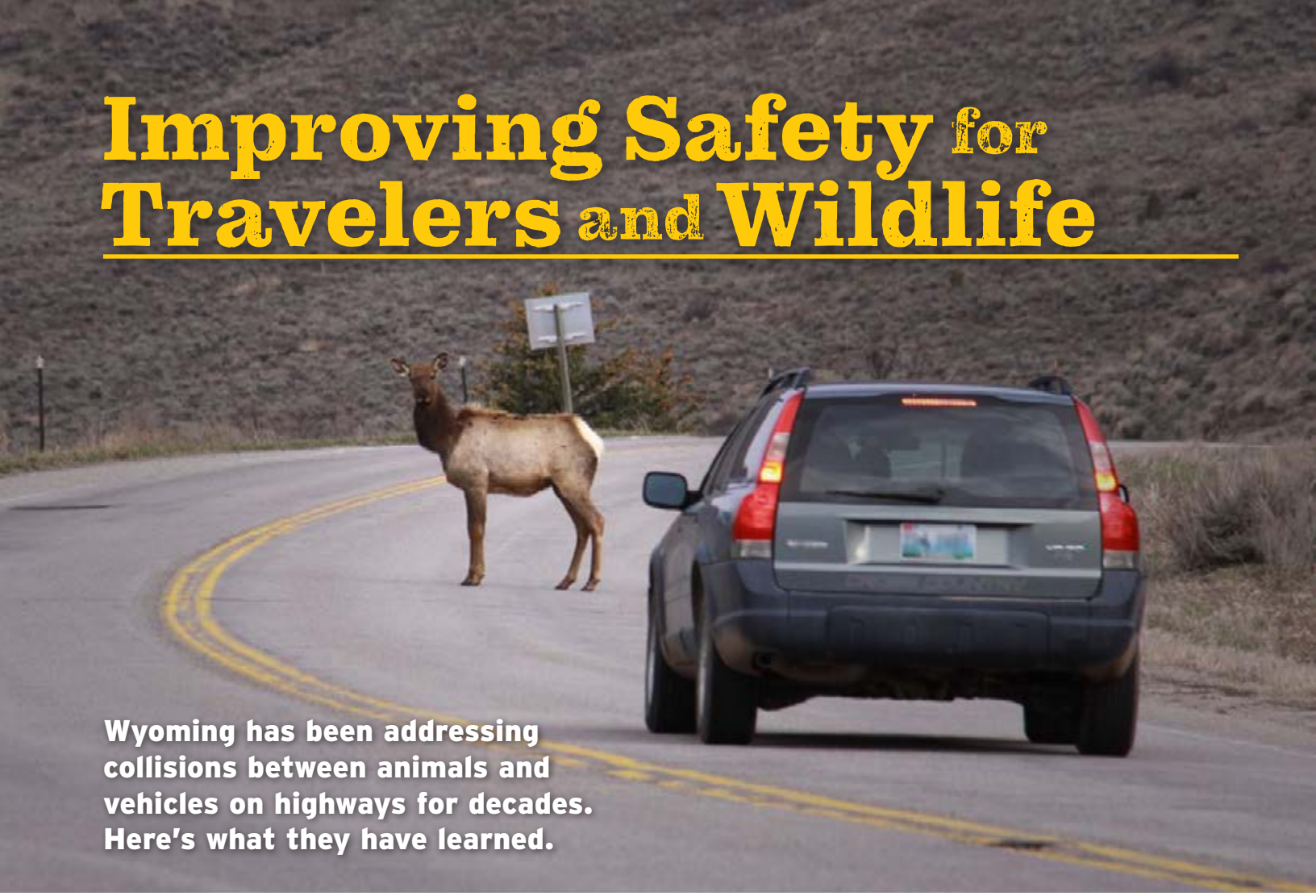
For more information, see *www.fhwa.dot.gov/engineering/hydraulics* or contact Eric R. Brown at 202–366–4598 or *eric.r.brown@dot.gov*.

Improving Safety for Travelers and Wildlife



Wyoming has been addressing collisions between animals and vehicles on highways for decades. Here's what they have learned.

In Wyoming, vehicle/wildlife conflicts are common on highways. WYDOT and its partners are working to mitigate the issue and improve safety for travelers as well as animals.

© Mark Gocke.

by **BOB BONDS**, **SCOTT GAMO**, and **THOMAS HART**

Roadways inevitably bring conflict between wildlife and vehicles, especially on rural highways, leading to carcasses in or beside travel lanes, injured animals, damaged vehicles, and injured people. Wyoming is no exception. As in other States, Wyoming roadways commonly overlap, intersect, or travel along common wildlife habitats and migratory corridors.

One of the ways to help keep migration corridors intact while improving safety for travelers and wildlife is to provide highway crossing structures in select locations. In Wyoming alone, studies have shown an approximate 80-percent reduction in wildlife/vehicle collisions where such structures have been installed. While obviously benefitting wildlife, these structures ultimately serve transportation agencies by addressing their highest priority—traveler safety. Although such additions to roadway design can be expensive, they provide worthwhile benefits to wildlife and the traveling public, such as reducing crashes, injuries, property damage, emergency response, and carcass removal and disposal.

Understanding Wildlife/Vehicle Conflict

To improve safety and prevent collisions, transportation agencies must first have data on where the wildlife is, how animals are moving, and where conflicts occur. With the advent of GPS technologies incorporated into radio telemetry collars, wildlife researchers could begin to identify migration corridors for mule deer and pronghorn—two of the most common species in Wyoming's wildlife/vehicle conflicts—and identify these routes in Wyoming. In addition, the Wyoming Department of Transportation (WYDOT) has long been collecting carcass location data along highways. Combining these long-term data with new telemetry data has greatly improved identification of hot spots and helped focus priorities to mitigate wildlife/vehicle conflicts.

Wyoming is home to some of the longest intact mule deer and pronghorn migration corridors in North America.

"The vast majority of deer, elk, and pronghorn are migratory, so it's important we maintain functional migration corridors that allow them to move between distant winter and summer ranges," says Hall Sawyer, a research biologist and project manager with Western EcoSystems Technology, Inc.

In February 2020, Wyoming Governor Mark Gordon recognized the importance of these migration corridors when he signed an Executive Order outlining their protection and management.

While many collision areas correlate with migration corridors, other hot spots are due to more localized animal populations, vehicle densities, and speeds. Conflicts arise in nonmigration areas such as seasonal or year-round wildlife habitats.

Typically, wildlife/vehicle collisions result in a low percentage of fatal and injury crashes. However, conflicts with large game animals comprise 15 percent of overall crashes in Wyoming, and of these, 80 to 85 percent involve mule deer. Fortunately, very few collisions have resulted in human

Wildlife/vehicle conflicts–and collisions–in Wyoming occur across all highways statewide.

© Mark Gocke.

2013-2017

Crash Severity	Total Crashes	Wildlife Caused	Wildlife Crashes Percentage of Total
Fatal Injuries	540	6*	1.1%
Injury Crashes	13,387	282	2.1%
Property Damage Only Crashes	54,882	12,275	22.4%

*5 of the 6 fatal injuries were individuals riding motorcycles.

fatalities, although the same cannot be said for wildlife. Regardless, wildlife/vehicle collisions result in tens of millions of dollars in vehicle repairs, as well as roadway maintenance costs to dispose of carcasses. In addition, it is becoming more difficult to dispose of carcasses as fewer and fewer municipal landfills are accepting them, forcing WYDOT to find alternative sources such as paying for private contracts.

Early Methods to Mitigate Conflicts

WYDOT's initial attempt at reducing wildlife/vehicle conflict in the State began in the 1980s with the installation of wildlife barrier fencing at the right-of-way boundaries on select highways. This was a cooperative effort between WYDOT and the Wyoming Game and Fish Department (WGFD) as the two agencies worked to identify the best locations to implement the new fencing. Wyoming now has more than 25 miles (40 kilometers) of wildlife barrier fence on I–80, 4 miles (6.4 kilometers) on I–25, and 35 miles (56 kilometers) on several other highways.

In the early 1990s, WYDOT and WGFD initiated a focus on facilitating mule deer migration across Wyoming roadways based on information from research studies on U.S. 30 west of Kemmerer, WY. This section of road experienced hundreds of deer/vehicle conflicts annually. In 2001, WYDOT mitigated the issue by installing a reinforced-concrete box culvert at Nugget Canyon with associated wildlife barrier fence to facilitate animal movement toward the culvert. WYDOT monitored the 11-foot-high by 20-foot-wide (3.4-meter by 6-meter) culvert structure to determine effectiveness after installation. The agency constructed numerous facias, or temporary openings of various sizes, to determine the minimum size that mule deer preferred. Researchers found the 10-foot by 20-foot (3-meter by 6-meter) configuration to be the optimum dimensions. WYDOT subsequently installed six more underpasses and associated barrier fencing along U.S. 30. This successful wildlife crossing effort has reduced wildlife vehicle collisions by 81 percent.

The Nugget Canyon box culvert provides a safe crossing point on U.S. 30 for wildlife. Wildlife fencing helps channel the animals into the culvert and away from the open highway.

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Moran Junction to Dubois Road

In the mid-2000s, WYDOT convened the first wildlife working group to support the Moran Junction to Dubois highway reconstruction (U.S. 287/26) project. The wildlife working group included representatives from Federal Highway Administration, WYDOT, WGFD, the U.S. Forest Service, U.S. Fish and Wildlife Service, and a local wildlife advocate. The group was tasked with developing a process to review potential crossing locations and structure types. The group evaluated structures to fit natural topography and drainages, and identified crossing locations based on research projects and local knowledge.

The Moran Junction to Dubois corridor is a high-elevation project along the southern Greater Yellowstone Ecosystem and is located in core spring, summer, and fall habitats, rather than along a migration corridor. The road, within Bridger-Teton and Shoshone National Forests, receives more than 300 inches (760 centimeters) of snow each winter and therefore cannot support a fence of any kind—the snow load would destroy it in one season. To address wildlife/vehicle conflicts in this environment, the working group recommended extending two bridges, creating an under-passage on each side, as well as adding a new bridge, four new large box culverts, and a large arch culvert. Less than 10 percent of the project's $120 million cost went toward these wildlife mitigation strategies. The structures have proven to be effective for facilitating safe crossings by mule deer, elk, moose, and grizzly bear, as well as numerous small mammals.

"An extra selling point was the structures could also be used by snowmobiles in the winter without wildlife conflict, as most species migrate to lower elevations or hibernate," says Mark Hinschberger, a retired wildlife biologist formerly working in the Shoshone National Forest.

The collision mitigation structures built to improve safety for the Moran Junction to Dubois Road project have proven effective for deer, moose, and even bears.

© Carol Theis, Bridger-Teton National Forest.

Highway 789 Underpasses

North of the town of Baggs, WY, State Highway 789 bisects crucial winter range and migration corridors for mule deer. Oil and gas production in the area contributed to a drastic increase in deer/vehicle crashes. With funding help from WGFD, Wyoming's Bureau of Land Management, the local conservation district, and other nongovernment organizations, WYDOT constructed two 10-foot by 20-foot (3-meter by 6-meter) box culvert underpasses and approximately 5 miles (8 kilometers) of barrier fence in 2009 and 2012 to mitigate deer/vehicle crashes. As in Nugget Canyon, the underpasses have been very effective at safely moving mule deer under the highway. WYDOT and its partners documented more than 16,000 mule deer crossings during the first 2 years after construction of the first underpass and more than 1,200 crossings during the first 7 months after construction of the second underpass. Other species such as elk, bobcat, and coyote have benefitted from the underpasses as well.

Pronghorn tend to travel across open, high-visibility areas, like the roads along the Trappers Point corridor.

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Trappers Point

The Trappers Point project is perhaps Wyoming's most famous. Pronghorn and mule deer migrate through this area and, according to wildlife researchers, have done so for thousands of years. This important and long-length migration corridor, known as the Path of the Pronghorn, was even documented by National Geographic.

The wildlife migration corridor intersects U.S. 191 near Pinedale, WY. In addition, there are small private acreages and other developments that, combined with the highway and topography, create a bottleneck for wildlife to navigate, increasing the risk of vehicle conflict. WYDOT, with support of other agencies, installed two overpasses and six underpasses, along with a barrier fence

Pronghorn antelope travel a 170-mile (270-kilometer) migration corridor that runs from Grand Teton National Park to the Pinedale/Green River Valley area. Shown here is one of the two concrete arch wildlife overpasses at Trappers Point. An 8-foot (2.4-meter) wildlife barrier fence is needed to funnel animals to the crossings.

© Mark Gocke.

Buried Bridge at Togwotee Pass provides safe passage for elk and deer to move back and forth under the highway, minimizing potentially dangerous conflicts between wildlife and vehicles.

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to guide animals to the structure to help mitigate this crossing issue. Pronghorn tend to prefer open areas with greater visibility, so they tend to prefer overpasses. However, recent data show that the animals can habituate to underpasses that provide appropriate openness. Mule deer are less selective of structure type. Monitoring has since shown that the project has resulted in an 80- to 90-percent reduction in collisions while maintaining this critical migration corridor.

Togwotee Pass and Hoback Junction

Built in 2010, the buried bridge on Togwotee Pass cost approximately $2 million. The roadway is on a curve and has a 6 percent grade, and with an elevation of 9,500 feet (2,900 meters), can experience ice accumulation most months of the year. To minimize differential icing between the roadway and the overpass, WYDOT designed 3.5 feet (1.1 meters) of soil between the structure and surfacing. Travelers don't even realize they have traversed a bridge. The structure enables elk and deer to move back and forth under the highway along the reestablished drainage.

Like Moran Junction, the Hoback Junction to Jackson project also used a wildlife working group to develop a prioritized list of crossing locations and structures. The group recommended lengthening three bridges, building two new bridges, and building a new box culvert along with the associated wildlife barrier fence. The project consists of a north and south phase. The north phase is complete, with two new lengthened structures and one new bridge. The new and longer Flat Creek Bridge has remote camera data showing use by deer, moose, and elk—and even a family of mountain lions.

Looking to the Future

Transportation and wildlife agencies, along with Wyoming's Bureau of Land Management, the U.S. Forest Service, nongovernmental organizations, and Wyoming landowners, continue to work together on wildlife/roadway related issues in the State. In 2017, WYDOT and WGFD, along with their Federal, State, and local partners, created the Wyoming Wildlife and Roadways Initiative (*www.dot.state.wy.us/wildlife-initiative*) to improve public safety on the State's highways, reduce loss of lives and property, and reduce wildlife mortality.

The initiative established a collaborative group to prioritize a list of about 240 locations for potential wildlife/roadway projects across the State. The group determined the top 10 projects for WYDOT and WGFD to focus on for the foreseeable future. The list includes the Dry Piney project that has been awarded a BUILD grant. The highway bisects deer and pronghorn migration. The agencies are exploring efforts for funding opportunities by nongovernment organizations and other partners in this statewide effort.

By reducing conflicts between wildlife and vehicles, like this moose facing down a driver on a winter road, Wyoming is making its highways safer for all users–human and animal alike.

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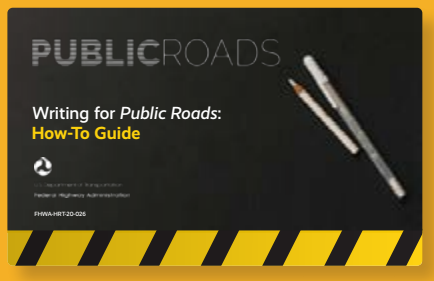

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SAVVY CITY FINANCING SUPPORTS FUTURE INFRASTRUCTURE

Using value capture techniques enabled Santa Monica, CA, to build out a fiber optic network without taking on debt, positioning the city to better meet the demands of new mobility modes and emerging transportation technologies.

Santa Monica's CityNet fiber optic network has enabled the city to better respond to transportation challenges and opportunities.

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by **THAY BISHOP** and **COURTNEY CHIAPARAS**

The city of Santa Monica, an affluent community in western Los Angeles County, CA, has a land area of about 8.4 square miles (21.8 square kilometers) and a population of more than 90,000, but its workday and weekend populations swell considerably. Workplaces and beaches draw 300,000 on weekdays and more than 500,000 on weekends, according to one estimate. The resulting traffic is so bad that the Los Angeles County Metropolitan Transportation Authority recently considered implementing congestion pricing for the city.

In the next decade, Santa Monica will need to integrate new technologies, such as drones and connected vehicles, into its transportation system. The city, like other localities around the country, will need to access new sources of revenue and enough communications bandwidth to enable the new technologies. Santa Monica's innovative approaches to using the public right-of-way (ROW) offer a strong example of how to achieve both objectives at once.

TELECOM HITS THE STREETS

Local traffic congestion in Santa Monica became a subject of particular interest in the late 1990s, when the need for infrastructure improvements in the public ROW threatened to disrupt traffic and access to local businesses. The Telecommunications Act of 1996 deregulated the broadcasting and telecommunications markets. Across the country, policy changes were leading to more permit requests to build new networks in the public ROW. Telecommunications construction was likely to add to congestion and shorten the lifespan of streets, particularly because firms wanting to hide their investment plans from competitors were often reluctant to engage in joint trenching.

At the same time, Santa Monica was facing a growing need for fast, reliable, and affordable broadband services to meet its internal communications needs. In 1998, Santa Monica published a telecommunications plan recommending that the city install its own fiber optic network to connect with key public facilities, such as the local community college, K–12 school district, and city buildings. The plan also included recommendations for managing the public ROW and leveraging public works projects to efficiently install telecommunications infrastructure. Rather

than leasing expensive lines from the cable company, Santa Monica could invest those funds in building its own network in phases across the city. Using this approach, Santa Monica was able to build an extensive fiber optic network without incurring debt.

In 2010, the city designed and launched a 10-gigabit fiber network, Santa Monica CityNet, to deliver its own broadband for city operations and local businesses. Today, CityNet offers up to 100 gigabits of dedicated broadband capacity through a fiber optic network serving the city's major hospitals, medical clinics, community college, police and fire stations, libraries, and nearly all the tech and entertainment businesses in the city. The city also offers free Wi-Fi in city buildings, in the public ROW, and at other locations across the city. It recently began offering commercial broadband services to residents as well.

Leasing fiber to other service providers and providing services to local businesses has resulted in millions of dollars in revenue, which CityNet invests back into the network through equipment replacement, staffing, innovation, and special initiatives. That practice, along with the incremental expansion of the network over the years, holds important lessons for agencies large and small looking to capture value from their own infrastructure investments.

CAPTURING VALUE FROM THE PUBLIC ROW

Beginning in 2002, as Santa Monica agencies opened the streets for a variety of projects, the city was able to install conduit and fiber underground. Laying the infrastructure in coordination with other capital projects that involved trenching—including street-widening construction, streetlight wiring upgrades, and replacement of irrigation mains—enabled a gradual extension of the network over the years. It also reduced the costs of installation by up to 90 percent and helped Santa Monica avoid redundant digging, which increased the lifespan of its streets and reduced traffic disruption.

When deploying the cable, Santa Monica placed extra fiber so that it could oblige higher demand and curb the costs of having to lay more cable later. Higher demand surely came. Google and other large

Wi-Fi supports a range of services, including traffic cameras and synchronized traffic signals, at intersections across the city.

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Beginning in 2002, as Santa Monica agencies opened the streets for a variety of projects, the city was able to install conduit and fiber underground. Laying the infrastructure in coordination with other capital projects enabled a gradual extension of the network over the years and reduced the costs of installation by up to 90 percent.

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businesses began leasing the city's dark fiber—unused optical fiber that is available for use in communication—which offers very fast, direct, low latency connections. Businesses that needed the dark fiber paid to connect it directly to their buildings, thus extending the network at no cost to the city.

Leasing the fiber installed in the public ROW is an important technique of value capture, which can harness a portion of the revenue from the lease to pay for city initiatives. ROW use agreements involve the sale or lease of development above, below, or adjacent to transportation ROWs or real properties. By tapping into ongoing revenue sources, value capture can raise funds for projects or provide a stream of funds on a long-term basis.

Value capture is useful in urban, suburban, and rural settings, and there are tools and techniques agencies can use in each of those settings, but it is particularly useful for local governments.

"Federal resources aren't necessarily growing enough to keep up with the needs across the country for highways and bridges," says Stefan Natzke, the team leader for National Systems and Economic Development in the Federal Highway Administration's Office of Planning, Environment, and Realty. "There is a scarcity of resources and increasing demand. On top of that, about three-quarters of public roads aren't eligible for any Federal funding. The diminishing or constrained resources are really hitting local governments particularly hard. They are looking for ways to find sustainable, long-term funding that can support transportation projects."

Value capture also has the potential to boost local economies. "If a project is well-designed and well-executed," Natzke says, "it can support positive economic development outcomes in a region. So, these are self-reinforcing, where good transportation can lead to economic development, which can lead to demand for better transportation."

In Santa Monica, CityNet has had a significant impact on the local economy, attracting tech and entertainment companies to the city and helping businesses lower their costs for high-capacity connections and retain and generate jobs in the community. For example, UCLA Medical Center, Santa Monica connected to the network and then hired 180 software developers to implement

CITYNET NOTABLE MILESTONES

2006: Begins leasing dark fiber to Google

2010 to Present:

- Launches Santa Monica CityNet 10-gigabit fiber optic network
- Offers up to 100 gigabit broadband services
- Provides broadband to roughly 95 percent of tech and entertainment firms with Santa Monica offices
- Includes new focus on shaping, informing, and piloting the city's "smart city" strategy

2015: Launches Digital Inclusion Pilot, providing gigabit broadband service to affordable housing communities

2018: Begins piloting smart city initiatives

a telemedicine initiative. The historic oceanfront Fairmont Hotel offers 2 gigabytes-per-second broadband to guests and markets itself for technology conventions and media production. Real estate companies emphasize the value of broadband in marketing and pricing their properties. As the city connects its network to more businesses, a cycle has emerged where the costs of new connections decline, leading more businesses to request connections, and further reducing the cost of connections.

CAPTURING VALUE FROM JOINT DEVELOPMENT

Public-private partnerships are a feature of joint development, another value capture technique that describes a public agency or a group of agencies that partner with a private developer to improve the use of land near, above, below, or adjacent to infrastructure. In Santa Monica, joint development facilitated the deployment of fiber broadband infrastructure when the city coordinated with the private sector to fund the expansion of its network and engaged with private service providers to help offer broadband services to customers.

Broadband service and the telecommunication infrastructure that facilitates high-speed connectivity are essential for modern transportation systems. This is evident in Santa Monica, where free Wi-Fi in 32 hot zones is available not only at major tourist destinations but also along key commercial and transit corridors. The Wi-Fi contributes to a range of city services, including public safety video cameras, pay-on-foot parking stations, real-time parking information on signs and smartphones, traffic cameras, synchronized traffic signals, and a transportation management center. CityNet also provides wireless backhaul services to ensure 5G wireless coverage for the entire city, and is gearing up to offer services using its millimeter wave wireless network as well.

The network now supports advanced applications, like parking meters that accept credit cards and smart traffic routing, that lead to a higher quality of life for residents and visitors and a better environment for businesses. At the same time, not having to borrow funds has reduced the city's telecommunications expenses while increasing the availability of high-speed services for the city and area businesses.

But the work does not end there. The city commits itself to continuous innovation to keep up with the many new mobility options coming to market. Communities are demanding accommodations for all mobility modes, such as walking, biking, automobiles, and transit. Ridesharing services are well underway. Widespread use of connected and autonomous vehicles (AV) will soon become reality.

"People want to get around fast," says Gary Carter, the community broadband manager at CityNet. "[A major ridesharing company] started here. [A major electronic scooter-sharing company] launched here and—after a roller coaster ride of emergency policy analysis, enforcement, lawsuits, and negotiations—e-scooters are gradually evolving into a manageable mobility option. We recently demonstrated a geofencing solution that would automatically slow scooters down on our sidewalks."

In Santa Monica, CityNet has had a significant impact on the local economy, attracting tech and entertainment companies to the city and helping businesses lower their costs for high-capacity connections and retain and generate jobs in the community.

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VALUE CAPTURE TECHNIQUES

Value capture techniques take several forms. The most common mechanisms in the United States are:

- Air rights
- Impact fees
- Joint development
- Land value tax
- Negotiated exactions
- Sales tax districts
- Special assessments
- Tax increment finance
- Transportation utility fees

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Broadband service and the telecommunication infrastructure contribute to a range of city services, including real-time parking information on signs and smartphones and synchronized traffic signals.

Other startups in the city are developing autonomous helicopters and mapping the graphic information system coordinates for airspace for similar technologies.

"When we consider the rapid rate at which companies have introduced new mobility solutions into the ROW in the past decade," Carter said in a recent webinar hosted by FHWA, "it's obvious to us that we need a new [intelligent transportation system (ITS)] that can interface with and adapt to them all. It's a huge, expensive undertaking that will require a lot of talent."

ITS technologies use wireless communication to manage traffic flow and improve safety, facilitating medical emergency and fire response. Some States are using drones for facility management and maintenance, such as crawl drones in bridge inspection programs. This increases work productivity and reduces the size and cost of work teams.

"The go-to response as these technologies emerge is to stall and to regulate, but that only buys you so much time," Carter says. "What it will require is cities partnering with tech companies to create something that is the 3.0 of what we have now."

CityNet pilots and experiments with new technologies that it believes will benefit the public and position the city to best respond to anticipated challenges and technological advancement, rather than reacting after the fact. All CityNet revenue goes into its Community Broadband Enterprise Fund, which helps support the expansion and maintenance of the network. Consolidating and focusing all the revenue on CityNet enables the city to keep experimenting.

"In the ROW, there's tension between the innovators and the adoption cycle and the regulatory agencies," Carter says. "CityNet can help bridge that gap. For instance, we can help convey the need for 5G wireless service in small cells throughout the city, show how it will benefit the public, and make sure it rolls out the right way. And while a lot of people are hesitant about autonomous vehicles, our position is that it's better to assess the risks proactively than to react to them later.

"A lot of cities and municipalities are looking at ways to leverage their assets to generate or capture more value," says Carter. "Sometimes that value is financial, and sometimes it's the ability to innovate further. Here in Santa Monica, we're seeing both. The value we've captured from CityNet allows us to incubate civic tech opportunities."

THE BENEFITS

CityNet Labs is the incubator working to assess and test emerging technologies, many of which would impact the way the public uses the ROW. Its AV pilot involves staff and subject matter experts researching ways to manage AVs as a mobility option and is introducing this to residents to assess the potential traffic impacts.

Carter explains, "We envision that, in the near future, there will be control mechanisms to interface with autonomous vehicles, and we're seeking opportunities to leverage our network and partnerships to prepare for that future."

Such an interface requires a robust wireless network. "I wouldn't be talking about an AV pilot right now if we didn't already have the network in place," Carter says.

CityNet Labs is also pursuing a number of "smart city" initiatives. Smart cities use electronic sensors to capture real-time data to analyze and understand dynamic traffic patterns and trends and to aid in traffic management—a must as more mobility options hit the streets.


The city commits itself to continuous innovation to keep up with the many new mobility options coming to market, such as electronic scooters.

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"Transportation is the primary focus of our smart city initiative," Carter says. "At our Smart City Working Group meetings, people often ask who will pay the ongoing operational costs needed to manage these options and the public ROW, particularly when roads, bridges, and tunnels are underfunded."

Value capture techniques can certainly help, as Santa Monica has seen with the success of its city-owned network. CityNet earns roughly $2.5 million in revenue annually, funding both the expansion and maintenance of its network as well as projects like its AV and smart city initiatives.

It also funds community engagement initiatives, such as its Digital Inclusion Pilot, which has expanded CityNet broadband to 10 affordable housing properties to help low-income residents have better access to wireless services. A Community Development Block Grant from the U.S. Department of Housing and Urban Development is helping to fund a $1.85 million ROW construction project to connect an additional 29 buildings, and the city is using its revenue from a scooter-sharing company to build out additional connections. The new expansion will offer more than 500 families in low-income housing free broadband delivered to their community rooms and the opportunity to purchase affordable service delivered to their units. They may also participate in no-cost technology workshops offered onsite.

"For Santa Monica, value capture in the ROW is central to our efforts to adopt innovation-driven policy updates that are key to our local transportation strategy," says Carter. "It has not only generated revenue, but also it has directly had a social impact in terms of our affordable housing and social mobility efforts, as well as our economic development."

Organizations interested in ROW value capture projects should be careful to follow relevant Federal and State legislation and guidelines. Profits from the non-highway use of any right of way purchased with Federal funds since the 1980s (according to 23 USC 156) or improved with Federal funds (according to 2 CFR 200, effective through individual project agreements) need to go to projects eligible under Title 23 of the U.S. Code. In California, agencies should review the California Department of Transportation's ROW manual (*https://dot.ca.gov/programs/right-of-way/right-of-way-manual*), which describes how the non-highway use of any ROW is handled by the State. Other States may have similar documents.

EVERY DAY COUNTS

The FHWA Center for Accelerating Innovation (CAI) manages Every Day Counts (*www.fhwa.dot.gov/innovation/everydaycounts*), a State-based model that identifies and rapidly deploys proven yet underutilized innovations to shorten the project delivery process, enhance roadway safety, reduce traffic congestion, and integrate automation. For round 5, FHWA selected value capture as one of 10 innovations. CAI provides tools, resources, and technical assistance on value capture and other options to help the transportation community implement alternative financial strategies to deliver infrastructure.

FHWA's Natzke recently shared key lessons to help local governmental agencies, as well as transportation organizations, incorporate value capture into their projects.

"Start thinking about using value capture at the earliest stages of project planning. It's never too early," he says. "When you start thinking about potential funding sources for a project, it's probably a good time to start thinking about value capture and exploring what value capture options might fit in with your funding and financing plan."

As the case in Santa Monica demonstrates, value capture can help fund the infrastructure needed to support tomorrow's transportation system.

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For more information, visit *www.fhwa.dot.gov/ipd/value_capture* or contact Thay Bishop at 404–562–3695 or *thay.bishop@dot.gov*.

CityNet is pursuing a number of smart city initiatives to capture real-time data to analyze and understand dynamic traffic patterns and trends and to aid in traffic management.

DETECTING BRIDGE CORROSION with a ROBOTIC MAGNETIC-BASED NDE SYSTEM

FHWA is researching a promising nondestructive evaluation method to uncover corrosion in the Nation's prestressed concrete bridge girders.

In 2005, a catastrophic failure of a prestressed concrete girder caused a bridge to collapse onto I-70 in Pennsylvania. Nondestructive evaluation (NDE) techniques such as magnetic flux leakage detection can help prevent events like this.

© Pennsylvania Department of Transportation.

by **HODA AZARI** and **SADEGH SHAMS**

Concrete deterioration and steel corrosion are major concerns to bridge owners and engineers. The corrosion of steel reinforcement in concrete construction impairs the durability and longevity of prestressed concrete girders. Although steel reinforcing compensates for the weakness in tensile strength of the concrete, it is the leading cause of concrete deterioration.

Prestressed concrete is less permeable and has a higher alkalinity than normal concrete. However, steel reinforcement can be corroded in the case of poorly detailed or constructed systems, or when the environment is more severe than expected. The corrosion of the steel strands decreases the ultimate strength and ductility of strand and leads to fracture, and may cause premature failure of concrete structures. Concrete cracks form over prestressed steel strands, permitting water and de-icing chemicals to penetrate to the steel and accelerate corrosion and create delamination and spalling.

There are more than 617,000 bridges in the United States, most of which are constructed of steel, conventional reinforced concrete, or prestressed concrete.

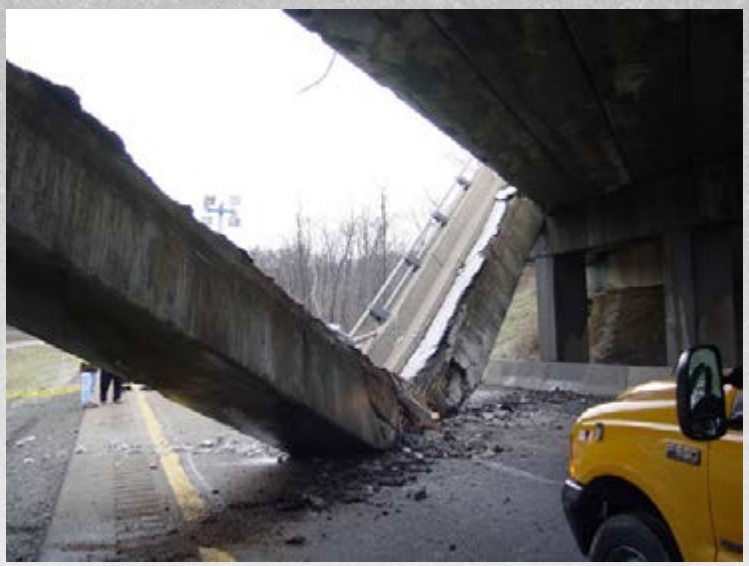
In 2002, the Federal Highway Administration, in partnership with NACE International released a benchmark study, *Corrosion Costs and Preventive Strategies in the United States* (FHWA-RD-01-156), on costs associated with metallic corrosion in a wide range of industries. The report estimated the annual direct costs for replacement and maintenance of bridges in poor condition to be $8.3 billion, but the indirect costs of corrosion incurred by users and owners increase exponentially. The report estimated the indirect costs to the user, such as traffic delays and lost productivity, to be as high as 10 times that of direct corrosion costs. In 2013, NACE International estimated the annual direct cost of corrosion for highway bridges to be $13.6 billion.

Catastrophic collapses have led to a reevaluation of the condition of many bridge structures, which results in bridges being posted for weight restrictions. For instance, on December 27, 2005, the SR1014 Lake View Drive Bridge in Washington, PA, collapsed onto Interstate 70 when one of the prestressed concrete girders failed from dead load. The forensic evaluation of the bridge revealed heavy spalling and corrosion of the strands on the bottom flange of the failed box beam member. Therefore, detecting corrosion in bridges is critical to effective maintenance and repair.

"As such, some NDE data are becoming essential for more effective and economical management of bridges, and concrete bridge decks in particular," says Dr. Joey Hartmann, director of FHWA's Office of Bridges and Structures. "To make more informed decisions addressing safety, reliability, and maintenance of bridge structures, owners have increasingly turned to NDE over the past 15 years to support bridge inspections."

Magnetic-Based NDE Implementation and Technology Plan

Corrosion is a progressive process, and, if left unrepaired, leads to steel section loss or fracture resulting in lowered member capacity. Timely inspections of bridge structures—coupled with appropriate interventions and mitigation strategies—significantly reduce the dollar impact of corrosion



by documenting the corrosion and allowing for rehabilitation of the structures to increase the life of these valuable assets. By developing new and improved evaluation techniques and testing devices, bridge engineers can more accurately determine inspection intervals, prioritize the most effective strategies for corrosion prevention and mitigation, and, ultimately, increase the service life of the Nation's bridges.

Since the late 1990s, FHWA has conducted several projects on the NDE of steel corrosion embedded in concrete bridges. The magnetic-based methods have been investigated through various projects seeking more efficient and cost-effective corrosion inspections of prestressed concrete girders. Studies have demonstrated that magnetic flux leakage (MFL) systems are an effective NDE means used in the transportation and energy industries to detect corrosion such as loss of general uniform thickness, stress corrosion cracking, and concentrated pitting.

MFL inspection relies on the fact that the gradient of magnetic scalar potential in a magnetized metallic object rises in approaching any loss or added material. The amplitude of the MFL is generally proportional to the magnetization level: the gradient can be significant when the ferromagnetic materials are locally magnetized to full or near saturation. For the purposes of examining prestressed concrete girders, the magnetizer travels the length of the prestressing strands to detect any flux leakage caused by section loss or gain. In other words, the MFL system, in the same manner with leakage from section loss at corrosion, identifies lateral reinforcements (stirrups) from added section at strand-stirrup interfaces.

The magnetic sources can be either permanent or electromagnets. However, permanent magnets have more versatile applications in the field because of their simpler hardware requirements and speedy operation. Sensors are located between two permanent magnet blocks and can pass near the defects to measure the resulting flux leakage field. Sensors can be mounted axially and normally with respect to the direction of the magnetic field, producing a voltage output that changes proportionally with the magnetic field. As concrete is essentially a nonmagnetic material with a relative magnetic permeability of unity, it has negligible influence on the magnetic measurements.

FHWA's NDE Laboratory developed a more effective and field worthy magnetic-based NDE system in 2019 for the detection of steel corrosion in AASHTO-type prestressed concrete girders. The new MFL system is designed by taking computational and analytical measurements using the finite element multiphysics method to size and lay out magnets and determine rare-earth metal strength, select the magnetic field detection sensor, and predict test outputs under corrosion sizes and different concrete steel placements. Sixty-four such sensors are laid out on eight printed circuit boards in 32 pairs along a straight line with a 0.25-inch (0.64-centimeter) spacing. Each pair of sensors represents one channel of data for the normal magnetic field and one channel for the axial field.

Virginia's MFL Research

Corrosion of reinforcement in concrete bridges is a major concern for the Virginia Department of Transportation (VDOT). This is particularly the case for prestressed concrete because

The magnetic flux leakage device includes 64 sensors placed on its circuit board.

Source: FHWA.

of the sensitivity of corrosion-induced cross-section losses on the strands under large tensile stresses.

"VDOT had found severely corroded prestressed strands in some bridge beams during inspections," says Soundar Balakumaran, the associate director at the Virginia Transportation Research Council (VTRC), which is part of VDOT. "This motivated VDOT and VTRC to explore technologies that are sensitive to cross-section losses in steel strands before the corrosion propagates to an advanced stage."

The research conducted at VTRC showed MFL as the technology with the most potential. VDOT built a rough prototype MFL device for laboratory testing and found it to be successful in identifying small cross-section losses in steel strands. Since a commercial device with this technology is not available at this time, VDOT has been looking to collaborate on the development of a production-level practical device for bridge inspection.

"FHWA's extensive testing reaffirmed the effectiveness of MFL technology for VDOT," says Balakumaran.

The Robotic MFL

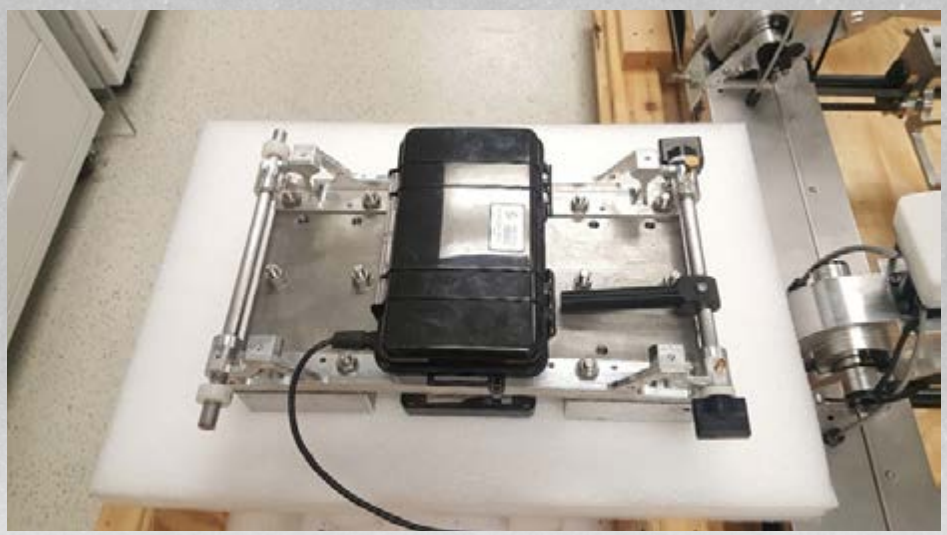
In the latest version developed by FHWA's NDE Laboratory, the MFL system is integrated into a robotic rover that travels the girder length using eight articulating arms engaged with the bottom flange on an AASHTO-type prestressed concrete girder. The robotic rover crawls along the length of the girders' bottom flange while an X-Y positioning carriage supports an NDE device. The rover is capable of navigating diaphragms such that four arm pairs move around obstructions sequentially. The new rover follows a modular scheme that allows different evaluation devices (payloads), other than the MFL, to be used for testing and evaluation of the AASHTO-type prestressed concrete girders.

The newly designed MFL system consists of two permanent magnets to magnetize embedded strands and multiple sensors to detect normal and axial MFL. The magnet and sensor assembly moves linearly along the length of the girder. The direction of the applied magnetic field is aligned with the longitudinal strands embedded in the concrete girder. When the assembly reaches either the interface with stirrups or a corroded section of the bottom layer of strands, the magnetic field will be distorted.

The primary components of the robotic rover subsystem include a rigid structural frame, articulating arms with drive mechanism, proximity sensors, NDE device carriage, two encoder wheels, control modules, a power source, and data communication devices. Communication between the main computer on the device and the

During testing, FHWA researchers installed the robotic rover on an AASHTO-type IV concrete girder at FHWA's Turner-Fairbank Highway Research Center.

Source: FHWA.



The MFL system comprises two permanent magnets, sensor arrays, data acquisition and communication, and a power source.

Source: FHWA.

different onboard microprocessors and the data acquisition system occurs via two independent wireless gateways, one that is dedicated to the robotic rover and one to the MFL detection subsystem.

FHWA researchers validated the robotized MFL system in the laboratory on a mockup girder specimen. The team investigated the effectiveness of the MFL method under several impacting parameters using finite element multiphysics simulations. They found that MFL signals can be influenced by the distance between the magnetizer/sensor array and the object of interest. However, operators should be aware that signals from nearby secondary ferromagnetic objects such as stirrups, tie wires, and steel chairs may interfere with MFL signals.

Researchers verified the real-world performance of the system by examining AASHTO-type prestressed concrete girders salvaged from an in-service bridge in Maryland. The girders were in service for almost 50 years before being salvaged from the bridge to be used for full-scale research at the Turner-Fairbank Highway Research Center.

The research team at FHWA's NDE Laboratory installed the robotic rover on the girder and established wireless communications with the integrated MFL system and ground controller. The developed software on the ground computer successfully controlled and monitored the scanning process. Using real-time data visualizations and further processing of recorded data revealed that the MFL system was able to disclose the location and extent of corrosion of prestressing strands and mapping stirrups.

Research Findings

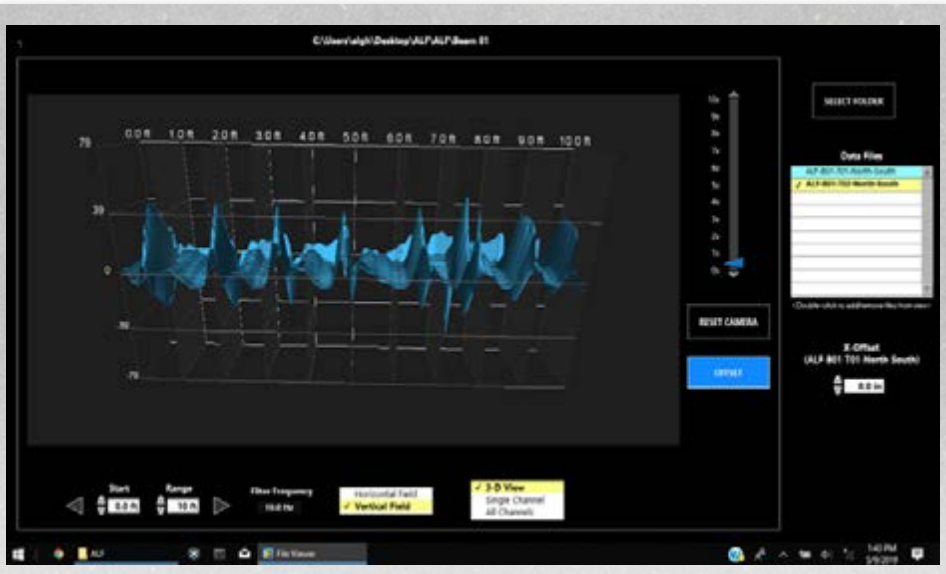
The research done in FHWA's NDE Laboratory in collaboration with the University of Wisconsin–Milwaukee has led to the development of a state-of-the-art magnetic-based corrosion detection system for use in prestressed concrete bridge girders. The system has benefitted from incorporating the latest technology, design, fabrication, and software engineering techniques. FHWA designed the MFL detection system using finite element multiphysics simulations to arrive at the optimum performance. The unique electronic circuits implemented in the data detection system enable the system to achieve extremely large dynamic range and excellent resolution, providing detection of corrosion-related cross section losses at less than 2 percent.

The robotic rover provides structural support and a platform for the payload so that it can be moved along the length of a test girder for magnetic scanning. The rover is a sophisticated computer-controlled robotic device designed and fabricated to navigate obstacles as it moves, making the system a more effective and field-worthy NDE tool. System software provides data visualization and analysis, including 3-D imaging of the measured magnetic field in two different orientations.

"FHWA's team subjected the MFL system to extensive laboratory testing and evaluation after its fabrication," says Dr. Jean Nehme, the team leader for FHWA's Long-Term Infrastructure Performance Team. "The testing and evaluation led to optimizing the system performance by enhancement of the components and the entire system."

HODA AZARI is the manager of the NDE Research Program and NDE Laboratory at FHWA's Turner-Fairbank Highway Research Center. She holds a Ph.D. in civil engineering from the University of Texas at El Paso.

SADEGH SHAMS is a contracted research engineer working in the NDE Laboratory at FHWA's Turner-Fairbank Highway Research Center. He holds a Ph.D. in civil engineering from the University of Wisconsin–Milwaukee.



The MFL software provides data visualization and analysis.

Source: FHWA.

MOVING FoRRRwD: Focus on Reducing Rural Roadway Departures

FHWA is partnering with State and local agencies to save lives on rural roads.

About one-third of the Nation's annual traffic deaths are rural roadway departures.

Source: FHWA.

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

Each year in the United States, nearly 12,000 people die in roadway departure crashes on rural roads. That is more than 30 people today, and every day.

It is easy to overlook how serious a problem this is because those deadly crashes happen in scattered locations across vast rural roadway networks. Rural roadway departure crashes (also called lane departures) do not cause massive traffic jams. There are no multicar pileups that make the news. They happen one here, one there, like a dripping faucet. Combined, however, those far-flung crashes account for roughly 30 percent of the Nation's annual roadway deaths. It is truly a national problem.

Is there a way to save the people behind those numbers? Can agencies, with increasingly limited resources, hope to reduce rural roadway departures on their systems? The answer to both questions is yes, but it is a formidable challenge.

The Federal Highway Administration is working with State departments of transportation, Local Technical Assistance Program (LTAP) centers, local agencies, and Tribal and Federal land management agencies across the country to combat this issue under the Every Day Counts initiative called Focus on Reducing Rural Roadway Departures (FoRRRwD).

The FoRRRwD team is promoting further use of proven strategies to reduce rural roadway departures. Many agencies are already implementing these strategies and are seeing positive results. The efforts of these agencies are getting people home safely who may have otherwise died.

"The scale of the rural roadway departure problem is sometimes hard to grasp because it happens largely in the background," says Matthew Enders, the technical services manager for the Washington State DOT. "Once you see it, though, it is obvious that we have to do something. We are passionate about helping agencies solve this problem."

FoRRRwD is based on four pillars: consideration of all public roads, a systemic safety approach, proven countermeasures, and safety action plans. This article focuses on two of the pillars—addressing the problem on all public roads and use of a systemic approach. A companion article in an upcoming issue of *Public Roads* will focus on proven rural roadway departure countermeasures and development of safety action plans.

Improving Safety On All Public Roads

Rural roadway departure crashes are a major problem on all public roads. Fifty to 60 percent of fatalities happen on roads typically maintained by State DOTs. That leaves more than 40 percent of rural roadway departure fatalities scattered across the 79 percent of the rural road mileage under the jurisdiction of the more than 3,000

Source: FHWA.

counties, 16,000 towns and townships, or other jurisdictions across the United States.

Any national strategy to reduce rural roadway departure deaths that does not address these non-State roads is only working on half the problem. This is a crucial point for three reasons. First, most local agencies have insufficient resources for dedicated roadway safety staff. That means it is difficult for them to learn or apply the latest safety analysis techniques or to collect the data necessary to support the analysis. Second, many local agencies have little or no crash data to use. Third, most local agencies lack sufficient funding to mount a concerted effort on reducing rural roadway departure crashes. Some U.S. counties are larger landwise than some U.S. States and have tens of thousands of lane miles to monitor. Because rural roadway departure locations are scattered and random, many local agencies may have difficulty getting a handle on the problem on their own.

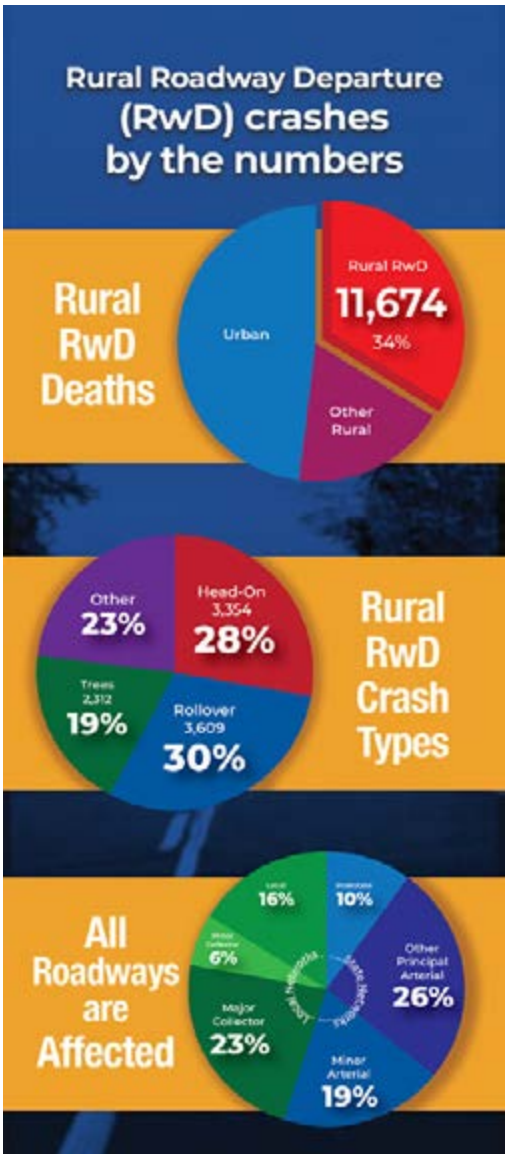
Partnerships Create Solutions

The national problem of deaths on rural roadways requires going beyond the State network of roads. It demands local partnerships to address the problem on all public roads. Several State DOTs, metropolitan planning organizations (MPOs), and regional planning commissions have stepped in to help their local counterparts. These agencies are making Federal and State funds available to local agencies based on the proportion of severe crashes happening on local systems. They are also making it easier for local agencies to apply for funding. And because data are key to this process, DOTs, MPOs, and regional planning commissions are helping local agencies with data acquisition, compilation, and analysis.

"Most drivers don't know if they are on a State or local road," says John Michael Walker, P.E., the State traffic and safety operations engineer for the Alabama DOT. "Those peoples' lives depend on the safety of all public roads, and that means all agencies working together."

North Dakota is another State assisting local agencies. They asked, "How do you to get to zero fatalities if you don't address the local road system?" According to Bryon Fuchs, assistant local government engineer with the North Dakota DOT, the State splits Federal safety funds fifty-fifty with local agencies, because that is the proportion of fatalities on each system.

Washington State DOT splits its Federal safety funds between the State, counties, and cities based on the proportion of fatal and serious injuries on each, which results in



Source: FHWA.

70 percent going to local agencies. Washington's LTAP Center is one of several that have jumped in to assist local agencies with data analysis.

The Louisiana Department of Transportation and Development (Louisiana DOTD) recently collected spatial coordinates of all public roads in Louisiana and loaded them into the agency's geographic information system (GIS). The effort resulted in a complete roadway basemap that Louisiana DOTD shares with local agencies.

The Acadiana Planning Commission (APC), an MPO in Louisiana, used the Louisiana DOTD GIS to inventory the roadways in their own jurisdiction. Together with Louisiana DOTD, the APC can now analyze safety using GIS data to integrate crash, roadway, and traffic volume data. The data analysis is invaluable for making informed safety investments and will provide justification to pursue funding.

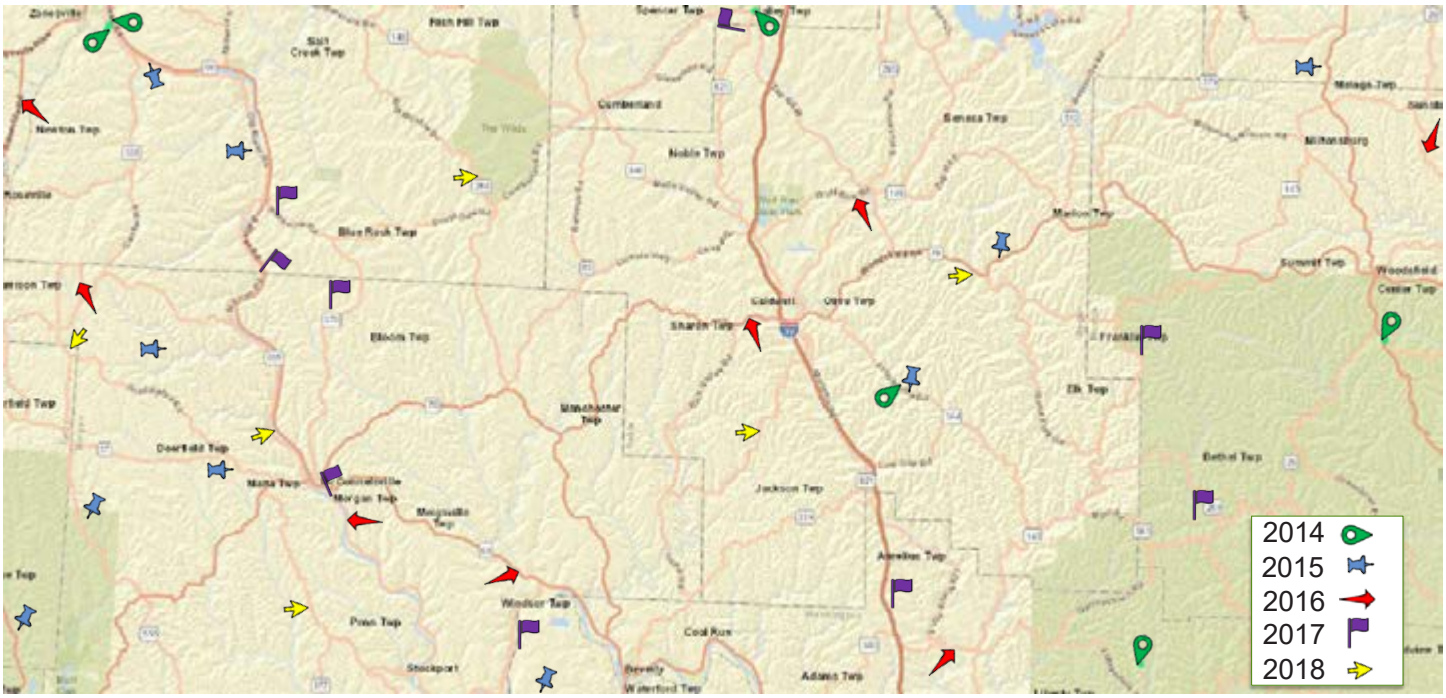
"The data collection and the tools developed by DOTD and the APC have been helpful in identifying locations where motorists have lost control of their vehicle and run off of the road on Acadia Parish's local roadways," says Michael Schexnider, the road manager for Acadia Parish. "Thanks to this data collection, we were able to plan and program a systemic roadway departure project to address curves on 12 roadways to reduce crashes in Acadia Parish."

The APC also works with Louisiana DOTD and local agencies to perform network screening and countermeasure selection. They help with asset management, roadway inventory updates, and a variety of other functions that may be beyond the resources of their local and parish-level partners.

These are the types of partnerships that are critical to address the crashes beyond the State system.

A typical rural local road may not have edge lines, shoulders, or signing. In some cases, the roads may not be paved.

Source: FHWA.



Hot spot analysis does not work well for rural roads, which tend to have widely scattered crash sites, as shown on this map of crashes on Ohio roadways for 2014 to 2018.

Source: FHWA. © ESRI (for map image).

Three Approaches to Safety

There are three approaches that most transportation agencies use to identify safety projects: "hot spot" analysis, systematic analysis, and systemic analysis. Some work better than others for certain types of crashes, and some work better for certain countermeasures. Ideally, they should be used together to be most effective.

Traditional Hot Spot Analysis

The hot spot approach uses historic crash data to identify sites with the most significant crash performance measures (such as crash frequency and crash rate). Sites with the highest numbers are deemed hot spots. Agencies identify hot spots, analyze the problem, and then install countermeasures to mitigate crashes.

Systematic Approach

With this approach, agencies install a countermeasure—rumble strips or SafetyEdge[SM], for instance—over an entire portion of their system meeting certain criteria, regardless of the number of crashes at any one location.

Systemic Approach

Systemic analysis (not to be confused with systematic) uses roadway geometrics, traffic characteristics, and maintenance information along with crash data to identify risk factors, then uses those risk factors to identify locations at highest risk of future crashes. Low-cost countermeasures are installed at targeted, high-risk locations across the system, even if there has not been a crash.

The Trouble with Hot Spots

While it is important that States review crash data to identify and address locations with concentrations of crashes (hot spots), this approach is not suited to the nature of rural roadway networks. Hot spots by definition are clusters of crashes at a single location. Hot spots may occur on roadways with high traffic volume and in urban areas, but are almost nonexistent on rural roads.

While the types of roadway departure crashes are fairly predictable (run-off-road or head-on collisions in horizontal curves, for example), specific crash locations are random from year to year, and they rarely happen at the same location multiple times. Because hot spot analysis depends on groupings of crashes at specific locations, it does not accurately reflect how rural roadway departures occur. Even if an agency finds a hot spot and mitigates it, doing so will not solve the larger problem because most crash locations will shift around the network each year. In addition, hot spot solutions are often expensive, such as rebuilding a curve or widening shoulders, which may involve purchasing right-of-way.

The other weakness of hot spot analysis is that it is reactive. It is based solely on past crashes, which leaves agencies waiting for a tragedy before anything can be done.

Is Systematic Feasible?

The systematic approach has advantages over hot spot analysis as it can be done proactively. For example, an agency can set criteria that mandate installation of SafetyEdge[SM] any time it paves a road without a curb, no matter the location. Adding safety treatments during other planned

SafetyEdge[SM] is a very low-cost countermeasure applied during the paving process. The gentle angle enables cars to return to the roadway safely following a departure.

Source: FHWA.

An FHWA engineer measures the angle of the SafetyEdge℠ installation during a new paving project on a rural road.

Source: FHWA.

projects like widening shoulders when overlaying an existing narrow road can be cost-effective.

However, the systematic approach does not apply countermeasures where they are most needed. It does enable safety improvements to be added, but other priorities often determine the order in which projects are completed, rather than where the highest risks can be reduced. Therefore, safety improvement installations across the network are often delayed. It can also be costly. Few agencies, especially local ones, have the money or staff to install and maintain every safety feature on every mile of road, even when limiting the use of countermeasures based on standard criteria.

Another key concern with this approach is that systematic criteria can be exclusionary. For example, agencies often exclude the use of rumble strips on narrow shoulders because of bicyclist concerns. However, roads with narrow shoulders tend to have higher risk of serious roadway departure crashes and would be a good location for rumble strips. Widening shoulders is beneficial to both bicyclists and to reduce roadway departures, but can be cost-prohibitive and in conflict with environmental goals. As a result, it is possible to miss high-risk locations when applying systematic policies.

It is therefore not effective to use only the systematic approach to solve the roadway departure crash problem.

A Systemic Approach Works For Health and Roadways

The systemic approach has benefits over both the hot spot and the systematic approach. It is proactive, targeted, and more cost-effective than the other methods. It looks not only at where crashes have occurred in the past, but the factors at those locations that likely contributed to the crashes. It then uses those identified risk factors to prioritize potential countermeasures and where they should be applied first to do the most good.

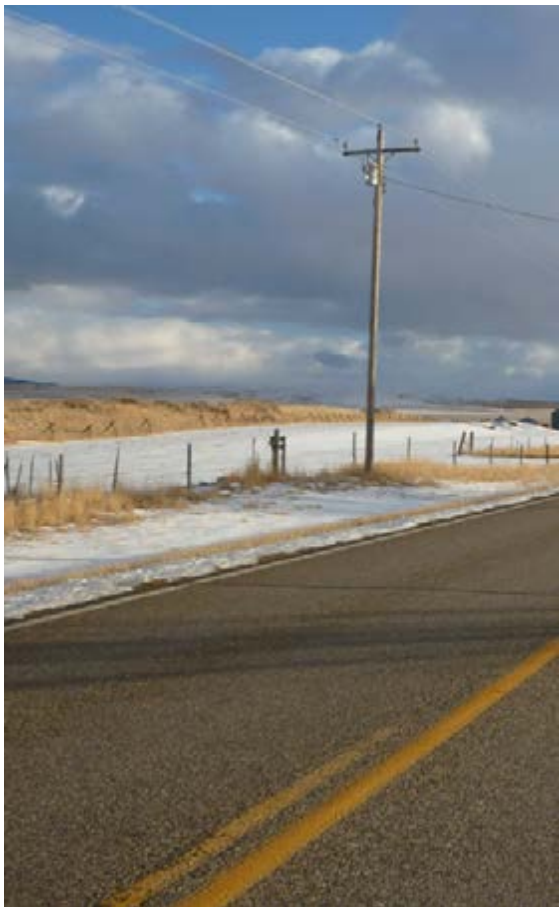
Systemic analysis sees a roadway system like a doctor does the human body. When you go for a physical, the doctor starts with data specific to you, such as your weight and blood pressure, then moves on to your medical history. Does anyone in your family have a heart condition? Diabetes? What about high cholesterol? The doctor then asks about personal habits. Are you a smoker? How often do you exercise?

Physicians understand that the human body is a system, and studies on large groups of people over long periods of time give them information on how various factors contribute to disease. Therefore, the doctor assesses the body system, looking for risk factors that may indicate future disease—enabling a proactive approach. Someone with multiple risk factors for heart disease, for example, can be prescribed treatment to fend off a heart attack. It would be unethical to wait until the patient had a heart event to recommend action.

Systemic analysis assesses a roadway system like the doctor. It starts with network crash data: Where have crashes happened? Compiling those data provides context to identify commonalities that exist in the roadway or traffic features that may have contributed to the crashes. If an agency does not have data of its own, data from similar roads elsewhere in the region, State, or nation may help determine appropriate risk factors. This is where systemic analysis departs from the hot spot approach. Instead of only mitigating locations of past crashes, the systemic approach also treats other locations that have similar features to typical crash locations.

Suppose a local agency finds that, out of 10 rural curves with injury crashes, 8 of those curves had a radius between 500 and 1,000 feet (150 to 300 meters). Now suppose six of those curves had no edge lines.

Just like the doctor knows high blood pressure and lack of exercise are risk factors for heart disease, it would be logical for the agency to conclude that other curves with a radius between 500 and 1,000 feet (150 to 300 meters) and no edge lines are at higher risk of rural roadway departures, even if



The presence of a visual trap (where it appears the road goes straight when it actually curves) is a qualitative risk factor that an agency might use in its systemic analysis.

Source: FHWA.

one has not happened yet. It would also be logical to install edge lines and perhaps other treatments, such as chevrons, at all curves with those same risk factors, across the entire system.

The systemic approach lets agencies target their investments to the locations at highest risk of severe roadway departures. It uses past data to assess risk of future crashes and prevent them. It lets safety set the agenda.

"It really opened up my eyes, and my staff's eyes, to what our problems are across our system," says Thomas Mattson, the director of public works for Humboldt County, CA. "Systemic lets you step back and say, 'A problem can occur anywhere on my system, what are the probabilities and what are my best methods of stopping that kind of problem across the entire system?' "

That is the breakthrough of systemic analysis and why it is one of the pillars of the FoRRRwD approach. Agencies can identify sites for safety improvement based on focus crash types (such as run-off-road), facility type (such as two-lane rural roads), and risk factors (such as tight curves).

The Benefits of the Systemic Approach

A key benefit to the systemic approach is that agencies can use the data they have now—even minimal data. This addresses the dearth of data for most local agencies. By looking at traffic and roadway features, a systemic approach enables agencies to use information gleaned from studies in other similar roadway environments. More benefits are likely to be achieved with higher-quality data, but not having some data does not exclude an agency from being able to apply this approach.

"Everybody has some data. Use what you have to start," Mattson says. "If you have to get more data, go for it, but don't not do anything just because you don't think you have enough data."

An additional benefit to the systemic approach is that many of the countermeasures used to improve high-risk locations are low-cost. Agencies also do not have to wait for large capital projects to install some of the countermeasures. For instance, trimming vegetation and installing curve warning signs can be performed during routine maintenance.

"The systemic approach enables widespread, proactive deployment of low-cost countermeasures at the locations most in need, based on data," says Jerry Roche, manager of the Data-Driven Safety Analysis Program in FHWA's Office of Safety. "That surgical mindset is getting results."

We Can Do This

It is possible to reduce rural roadway departure crashes, but it will take a disciplined, national effort from agencies at all levels. These deadly crashes are a problem on all public roads, so they must all be considered.

Rumble strips have been installed for as little as 10 cents per linear foot—a low-cost countermeasure that can be deployed systemically.

Source: FHWA.

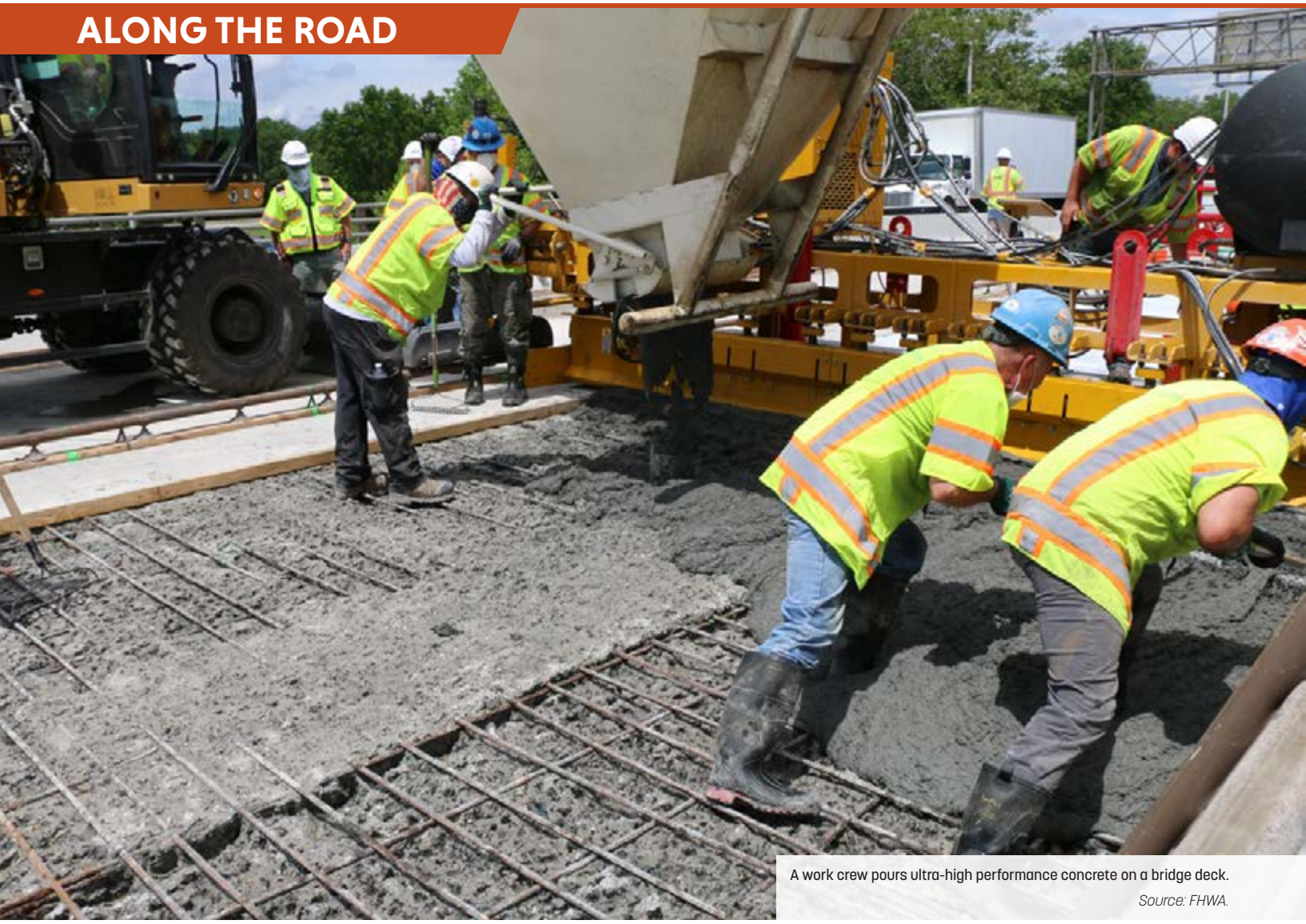
Partnerships between States, local agencies, LTAP centers, Tribes, and other agencies are critical to implement improvements to reduce these crashes. Agencies should also address their roads systemically, focusing on risk instead of crash history alone. An upcoming article in *Public Roads* will describe cost-effective roadway departure countermeasures and explain the value of developing safety action plans.

Thirty people will die today from rural roadway departure crashes. Let's save the people behind the numbers.

CATHY SATTERFIELD, P.E., is a roadway safety engineer in FHWA's Office of Safety, leading the roadway departure and visibility programs. She has a B.S. in civil engineering from the University of Minnesota.

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

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



A work crew pours ultra-high performance concrete on a bridge deck.

Source: FHWA.

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

FHWA Announces EDC-6 Innovations

On September 23, 2020, Federal Highway Administrator Nicole R. Nason launched Every Day Counts round 6 (EDC-6; *https://www.youtube.com/channel/UCIOFVzt6KnhH1cRm17LxBgA*). Seven innovations will be promoted in the State-based program to rapidly deploy processes and technologies to boost the safety and efficiency of the transportation system and keep America moving.

The EDC-6 innovations feature strategies to increase engagement with the people who build and use transportation infrastructure, new applications of products to save money on preserving and repairing bridges and roads, and processes to save time on project delivery and incident management.

The Federal Highway Administration's call for ideas for EDC-6 yielded more than 100 suggestions from local, State, and Federal agencies; academia; and industry. After consulting with the American Association of State Highway and Transportation Officials and other stakeholders, FHWA selected seven proven, market-ready innovations to promote in 2021 and 2022. They are Crowdsourcing for Advancing Operations; e-Ticketing and Digital As-Builts; Next-Generation Traffic Incident Management: Integrating Technology, Data, and Training; Strategic Workforce Development; Targeted Overlay Pavement Solutions; Ultra-high Performance Concrete for Bridge Preservation and Repair; and Virtual Public Involvement.

On December 8–10, 2020, FHWA will host a virtual summit to provide more details on the benefits of each innovation. Registration is free (*https://www.labroots.com/ms/virtual-event/fhwa-everyday-counts-6-virtual-summit*.) The 2-year deployment cycle begins in January 2021. EDC-6 deployment teams will provide technical assistance and training to help transportation agencies implement the innovations State Transportation Innovation Councils choose to adopt in their States.

For more information, visit *www.fhwa.dot.gov/innovation/everydaycounts/edc_6*.

The innovations for round 6 of Every Day Counts include Ultra-high Performance Concrete for Bridge Preservation and Repair.

Source: FHWA.

FHWA Expands Alternative Fuel Corridors

FHWA recently completed the fourth round of designations for the Alternative Fuel Corridors program. With the designation of these corridors, FHWA continues to establish a national network of alternative fueling and charging infrastructure along national highway system corridors.

To date, FHWA's Alternative Fuel Corridors Program has included 100 nominations submitted from State and local officials; designations of segments or entire lengths of 119 interstate corridors (including Hawaii and Alaska), along with 100 U.S. highways and State roads; 49 States plus the District of Columbia designated as corridor-ready or corridor-pending for one or more alternative fuel types; and an applied research funding opportunity for the deployment of alternative vehicle fueling and charging facilities.

In addition, FHWA released a summary report of the five regional Alternative Fuel Corridors convenings held in 2018 and 2019. The report contains information and perspectives from across the country on the installation of alternative fuel infrastructure along highway corridors. It is available at *www.fhwa.dot.gov/environment/alternative_fuel_corridors/webinars/summary_report*.

For more information, visit *www.fhwa.dot.gov/environment/alternative_fuel_corridors*.

Guidebook Assists States in Managing GIS Data

In late 2019, FHWA published the *Applications of Enterprise GIS for Transportation (AEGIST) Guidebook* (FHWA-HEP-20-014). The guidebook is the latest in a series of publications designed to help FHWA and State departments of transportation migrate to the enterprise level for creating, maintaining, and governing data related to roadways and their characteristics, elements, and events.

The publication's main objective is to document guidance on how spatial and linear referenced data should be managed by States. Developed by FHWA beginning in 2018 under phase I of a pooled fund study, the guidebook's goals are to facilitate deployment of enterprise data governance, develop a national specification for roadway data structure, advance State capabilities for safety analysis, and provide general instruction on data organization. The AEGIST project will help break down traditional management silos and answer enterprise questions such as: how autonomous vehicles can be accommodated, how agencies can compile and use federally required Model Inventory of Roadway Elements

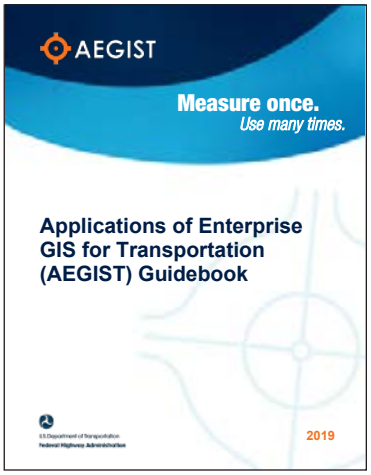
With the designation of alternative fuel corridors, FHWA is establishing a national network of alternative fueling and charging infrastructure.

© andrea lehmkuhl / Shutterstock.com.

data on highway safety, to what extent mobile devices with real-time traffic feeds are altering traffic patterns, whether there is a better way to respond to traffic congestion than by increasing roadway capacity on key routes, and how agencies can respond to increasing citizen data requests.

Phase II of the pooled fund study began in 2019 and spans 5 years until 2024.

The guidebook is available at *www.gis.fhwa.dot.gov/AEGIST.aspx*.



Source: FHWA.

Data Story Helps Practitioners Navigate Connected Vehicle Datasets

USDOT's Intelligent Transportation Systems (ITS) Joint Program Office offers the ITS DataHub, which currently hosts connected vehicle data from the Tampa and Wyoming Connected Vehicle Pilot sites. Data from the New York Connected Vehicle Pilot site will be added in the future. Datasets include basic safety messages, traveler information messages, and signal phase and timing messages, all of which are transmitted via dedicated short-range communications.

To help practitioners more easily understand the data available and how to access them, USDOT developed a Connected Vehicle Pilot "data story." This resource is available at *https://data.transportation.gov/stories/s/Connected-Vehicle-Pilot-Sandbox/hr8h-ufhq* and provides an overview of each Connected Vehicle Pilot, describes the types of data available, and walks users through how to access the various datasets.

ITS DataHub provides a single point of entry to discover publicly available USDOT ITS research data. By providing access to these data, the Department aims to enable third-party research into the effectiveness of emerging ITS technologies, preliminary development of third-party applications, and harmonization of data across similar collections.

To access all of the ITS DataHub's datasets, visit *www.its.dot.gov/data*.

FHWA Releases Whiteboard Videos on Highway Construction

FHWA's Office of Infrastructure Research and Development released a series of three animated whiteboard videos focused on specifications for highway construction to help improve quality. The videos are available on FHWA's YouTube channel.

Types and Uses of Construction Specifications (*https://youtu.be/-FfOUflbfF4*) introduces viewers to various types of specifications, including quality assurance specifications, warranty specifications, performance-based specifications, and performance-related specifications. *Quality Assurance Specifications* (*https://youtu.be/VeicnhCzn2A*) covers how quality assurance specifications work and highlights key aspects of a well-written quality assurance specification. *Performance Related Specifications* (*https://youtu.be/Lpu3ye1URrs*) covers how performance-related specifications work and includes steps involved in their development.

FHWA's animated videos discuss specifications for highway construction.

Source: FHWA.

Truck screening technology can save time and resources for drivers and inspection officers as freight enters Arizona.

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Technical News

ADOT Truck Screening Aids Freight Flow

To help freight move efficiently while ensuring that commercial vehicles can operate safely on State highways, the Arizona Department of Transportation (ADOT) has expanded its use of technology that screens moving trucks for weight and identifying information.

The system, previously used at select rest areas including McGuireville on I–17, Sacaton on I–10, and Canoa Ranch on I–19, is now operating at ADOT's commercial ports of entry along I–10, I–40, and SR–95 in Parker, AZ.

The technology includes weigh-in-motion sensors, cameras that are designed to read USDOT numbers and license plates, and message signs. An additional feature at the Ehrenberg and San Simon ports of entry on I–10 also identifies commercial vehicles with tires that could be damaged or in need of repair. The failure of a tire on a commercial vehicle can lead to catastrophic collisions and deposit tire debris on and along roadways.

As a commercial vehicle approaches the port of entry, highway signs direct the driver into the right lane. When the truck is a half-mile from the port, the weigh-in-motion sensors and cameras capture the vehicle's weight and identifying information and relay it to ADOT officers at the port.

The computer checks the truck's credentials against national and State databases. If the truck is cleared and within weight limits, the message boards along the highway direct the driver to bypass the port and continue on. If an issue is identified with the commercial vehicle, such as expired registration, Federal out-of-service orders, or required permits not on file, the signs direct the driver to pull into the port for further inspection.

In addition to saving ADOT officers and truck drivers time and resources, the system tracks and stores the size and weights of the commercial vehicles entering Arizona. These data will help ADOT's planning division make more informed decisions about the State's highway system in the future.

Policy and Legislations

USDOT Publishes Final Rule on Tribal Transportation Self-Governance

In June 2020, USDOT published a final rule to establish the Tribal Transportation Self-Governance Program at USDOT. The new program provides a flexible, effective framework for the Federal Government to work collaboratively with Tribes to improve transportation infrastructure delivery on Tribal lands and reservations.

This new rule, which went into effect on October 1, is the result of a multiyear negotiated rulemaking process between representatives of Tribes, USDOT, and the Department of the Interior. USDOT's Tribal Transportation Self-Governance Program recognizes the unique government-to-government relationship between the Tribes and the Federal Government and will improve the way USDOT does business with Tribes.

The program streamlines the Department's distribution of transportation funding to participating Tribes. Participating Tribes have greater autonomy in the management and delivery of transportation programs, including an enhanced ability to determine internal priorities, redesign programs, and reallocate resources to more effectively and efficiently meet their needs. The rule also streamlines transfers of grant awards that Tribes receive. The rule reduces regulatory requirements by harmonizing requirements applicable to various grant programs, streamlining the delivery of infrastructure.

The full text of the final rule can be viewed on the Federal Register at *www.govinfo.gov/content/pkg/FR-2020-06-01/pdf/2020-11618.pdf*.

Subsurface utility engineering can reduce utility conflicts and increase safety for highway construction.

Resolving Conflict in Utility Management

by **GAY DUGAN** and **AMBER CLARK**

Unknown utility conflicts on a highway project can result in increased risks to highway contractors, which translate into higher bids, increased hazards for highway workers and the public, and potential cost increases and delays during the construction of a project. The inability to obtain reliable underground utility information has long been a troublesome problem for highway designers across the United States.

To address the issue, some States have implemented a process of conducting subsurface utility investigations to accurately identify the location of these utilities. This engineering practice is known as subsurface utility engineering (SUE). The proper and successful use of SUE benefits both highway agencies and the impacted utilities, avoiding unnecessary utility relocations, eliminating conflicts with utilities, and enhancing safety.

Accurate utility information is available to highway designers early enough in the development of a project to allow them to "design around" many potential conflicts. This significantly reduces costly relocations normally necessitated by highway construction projects and reduces delays to the project caused by waiting for utility work to be completed before highway construction can begin.

Using SUE reduces or eliminates utility conflicts because the exact location of virtually all utilities can be determined and accurately shown on the construction plans. This reduces the number of delays caused by redesign when construction cannot follow the original design due to utility conflicts, or from cutting, damaging, or discovering unidentified utility lines. It also reduces the number of contractors' claims for delays resulting from unexpected encounters with utilities.

Effective SUE also increases safety. When excavation or grading work can be shifted away from existing utilities, damage to a utility that might result in personal injury, property damage, and the release of product into the environment becomes less likely.

Achieving Success with NHI

The National Highway Institute (NHI) recently launched two new courses in its Construction and Maintenance program area to help meet the training needs of Federal Highway Administration division officials, highway designers, and project managers. These new web-based trainings highlight the importance of using utility elements to help agencies achieve success in highway projects.

In spring 2020, NHI released one of its latest web-based trainings, Preparing and Communicating Effective Utility Relocation Requirements (FHWA-NHI-134117). This 3.5-hour course offers valuable information on the need for agreements and their requirements in the utility coordination process. Participants will learn to correct inefficiencies that may occur during the process in their specified projects.

"This class is critical to understanding the requirements that go into utility accommodation, relocation, and reimbursement," says Julie Johnston, a utilities program manager at FHWA's Office for Preconstruction, Construction, and Pavements.

Successful completion of this training requires participants to have basic plan reading ability and working knowledge of SUE.

Utility Investigations (course FHWA-NHI-134208) is a 3.5-hour self-paced training course, launched in May 2020. The course provides an overview of methods and practices for conducting utility investigations during project delivery.

"Utilities are one of the leading causes of delays in construction, and part of that is running into unknown utilities," says Johnston. "Effective utility investigation is a key part of reducing delays in construction."

Utility investigation is presented throughout the training as a comprehensive process to identify and document existing utility facilities. Participants will learn about the challenges that can occur from unknown utility conflicts and how to provide effective solutions to address them. This is an ideal course for people with basic plan reading ability, working knowledge of transportation project delivery methods, and high-level introduction to utility coordination.

There are no required prerequisites for the Utility Investigations course, but NHI strongly encourages learners to complete the Introduction to Utility Coordination for Highway Projects (FHWA-NHI-134006A) web-based training and Preparing and Communicating Effective Utility Relocation Requirements (FHWA-NHI-134117) web-based training prior to taking this course.

GAY DUGAN is an NHI training program manager.

AMBER CLARK is a contracted marketing analyst for NHI.

national highway institute

How to Attend or Host a Course

NHI invites professionals interested in earning continuing education units or professional development hours to visit *www.nhi.fhwa.dot.gov/home.aspx* 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 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 *www.nhi.fhwa.dot.gov/home.aspx*.

NHI is approved as an Accredited Provider by the International Association for Continuing Education and Training (IACET). As an IACET Accredited Provider, NHI offers continuing education units for its programs that qualify under the American National Standards Institute/IACET Standard.

Source: USDOT.

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Combating Human Trafficking

by **NICOLE BAMBAS** and **MAHA ALKHATEEB**

Nearly 25 million people globally are coerced or deceived into sexual or labor exploitation situations that they cannot escape. The limited transportation-related data available indicate that all modes of transportation are used to transport victims. A 2014 Urban Institute labor trafficking study of 122 survivors found that 71 percent were trafficked by flight and 52 percent were trafficked by car or van. A 2018 Polaris study of 104 survivors found trafficking across all modes: taxis (47 percent), airplanes (38 percent), public buses (33 percent), subway (19 percent), long distance buses (19 percent), long distance rail (11 percent), ridesharing (9 percent), and cruise ships (3 percent).

To address the intersection of human trafficking and transportation, the U.S. Department of Transportation works with public and private sector stakeholders to empower transportation employees and the traveling public to recognize and report possible instances of human trafficking. Counter-trafficking information, resources, and tools are available through USDOT's human trafficking website at *www.transportation.gov/stophumantrafficking*.

"The transportation sector is uniquely positioned to help fight human trafficking, and the Department has launched numerous initiatives to help transportation employers train their workers on how to detect and prevent it," says Transportation Secretary Elaine L. Chao.

"Public and private stakeholders across all modes of transportation can benefit from USDOT's numerous website resources to increase partnerships, raise awareness among employees and the traveling public, apply for funding, and advance their collective counter-trafficking efforts," says David Short, USDOT's Deputy Assistant Secretary for Aviation and International Affairs.

Transportation Leaders Against Human Trafficking

Site visitors begin with a video that highlights the Department's counter-trafficking efforts and calls transportation stakeholders to join USDOT's Transportation Leaders Against Human Trafficking (TLAHT) partnership (*www.transportation.gov/TLAHT*).

TLAHT is the Department's initiative to combat human trafficking in the transportation sector by maximizing the industry's collective impact through leadership, training and education, policy development, public awareness, and information-sharing and analysis. In January 2020, Secretary Chao brought a renewed focus to this important initiative, challenging the transportation industry to commit to "100 Pledges in 100 Days." Transportation leaders across the country heeded her call, and more than 200 signatories—double the original goal—committed to joining the Department on the frontlines of helping to ensure the safety of the traveling public. Links are provided for interested stakeholders to join TLAHT's 500+ partners and take action at *www.transportation.gov/TLAHT/TakeAction*.

Supporting Counter-Trafficking

To support transportation stakeholders in their counter-trafficking efforts, USDOT established grants and an award. The site links to grants that support counter-trafficking efforts through driver's license standards and programs in addition to

transit public safety, including human trafficking. Information about the Department's annual $50,000 Combating Human Trafficking in Transportation Impact Award is also included. The award aims to incentivize individuals and entities to think creatively in developing innovative solutions to combat human trafficking in the transportation industry.

The website notes the Department's counter-trafficking trainings for transportation employees. USDOT's 54,000 employees are trained every 3 years to recognize and report human trafficking, and the Department also developed a suite of trainings for the aviation, transit, rail, and motor coach industries in coordination with several partners and stakeholders. To date, 47 aviation industry partners have trained more than 100,000 employees under the Blue Lightning Initiative, and Amtrak has trained its 20,000 employees.

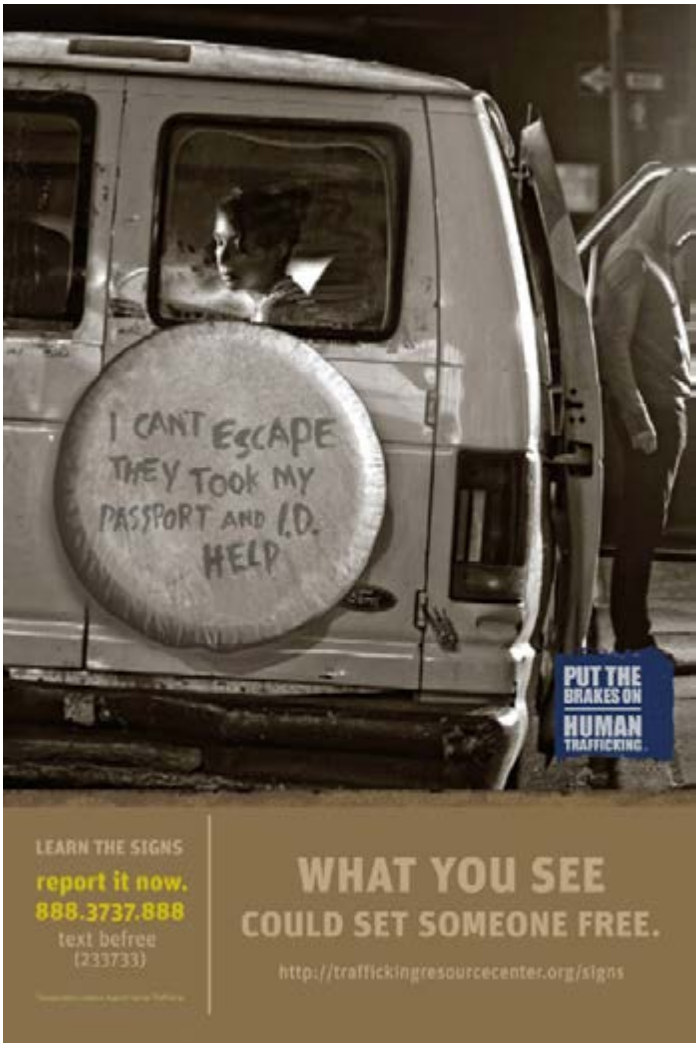
As raising public awareness is a key element in combating human trafficking, USDOT's human trafficking site includes links to the Department's multimodal logos, an indicator flyer, and print-ready posters. The Department also co-branded and facilitated the placement of public awareness campaigns by TLAHT partners at transportation hubs and billboards across the United States, including airports and Amtrak stations.

A key resource for all transportation stakeholders, the final report of the USDOT Advisory Committee on Human Trafficking (*www.transportation.gov/stophumantrafficking/acht*) includes counter-trafficking recommendations that all transportation stakeholders can implement and useful tools such as a model strategy with associated policies and protocols, a proclamation, training and awareness best practices, quick implementation guides by mode, and sample materials.

The site also spotlights legislation that has expanded USDOT's authority to combat human trafficking and touches on the Department's international engagement efforts on the issue.

USDOT's human trafficking site is available at *www.transportation.gov/stophumantrafficking*. Future updates will include expanded resources and tools to cover additional modes of transportation.

NICOLE BAMBAS is a senior policy advisor and **MAHA ALKHATEEB** is a transportation research analyst, both in the Office of International Transportation and Trade, Office of the Secretary of Transportation, which serves as the programmatic lead for USDOT's human trafficking initiative.



Print-ready awareness posters like these are available to download from USDOT's human trafficking website, along with other resources and materials.

Source: USDOT.

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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Safety Evaluation of Pedestrian Countdown Signals

Publication Number: FHWA-HRT-19-045

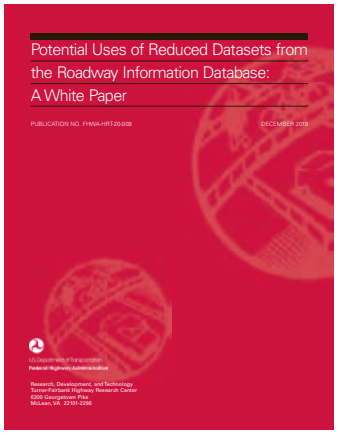
The research documented in this report was conducted as part of FHWA's Evaluation of Low-Cost Safety Improvements Pooled Fund Study. FHWA established this pooled fund study in 2005 to conduct research on the effectiveness of the safety improvements identified by the *National Cooperative Highway Research Program (NCHRP) Report 500* series as part of the implementation of the American Association of State Highway and Transportation Officials' *Strategic Highway Safety Plan*. The pooled fund studies provide a crash modification factor and benefit-cost economic analysis for each of the targeted safety strategies identified as priorities by the pooled fund member States.

This study evaluated the safety effectiveness of pedestrian countdown signals by conducting a before-after empirical Bayes analysis on data from 115 treated intersections in Charlotte, NC, and 218 treated intersections in Philadelphia, PA. The study results showed that after the implementation of pedestrian countdown signals, pedestrian crashes decreased by 9 percent, total crashes decreased by 8 percent, and rear-end crashes decreased by 12 percent. All these reductions were statistically significant. The economic analysis revealed a benefit-cost ratio of 23, with a low of 13 and a high of 32. This report will benefit safety and traffic engineers and safety planners by providing greater insight into pedestrian safety.

The document is available to download at *www.fhwa.dot.gov/publications/research/safety/19045/index.cfm*.

Potential Uses of Reduced Datasets from the Roadway Information Database: A White Paper

Publication Number: FHWA-HRT-20-009



The second Strategic Highway Research Program (SHRP2) Roadway Information Database (RID) is linked to Naturalistic Driving Study data. The level of coverage and accuracy of its mobile data, combined with the inclusion of supplemental data from existing sources, make the RID a powerful stand-alone database. Using the RID requires basic geographic information system (GIS) expertise, since the roadway data elements are conflated to a GIS-based network. To make data accessible to novice GIS users, FHWA developed reduced datasets that can be used off the shelf with basic programming skills. Making data more accessible will increase their use and application, thereby increasing opportunities for research to influence policies and practices that ultimately reduce the number of traffic fatalities and serious injuries on the Nation's highways.

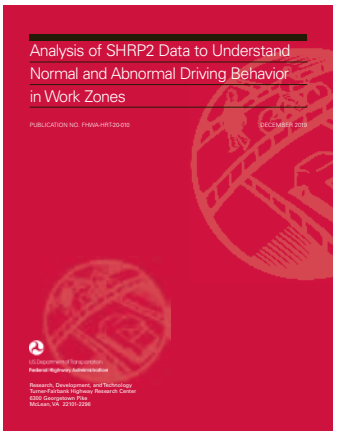
This report describes the potential highway safety research questions that can be addressed using reduced datasets. Potential research topics span seven topic areas: (1) crash predictions, (2) safety performance impacts of horizontal curve features, (3) safety

performance impacts of intersection features, (4) safety performance impacts of access management, (5) risk factors for systemic safety analysis, (6) crash assignments, and (7) driver awareness of signalized intersections when entering urban areas. This report will be of interest to individuals involved in highway safety, safety training, crash and injury reduction, roadway design and policymaking, and traffic operations and management.

The document is available to download at *www.fhwa.dot.gov /publications/research/safety/20009*.

Analysis of SHRP2 Data to Understand Normal and Abnormal Driving Behavior in Work Zones

Publication Number: FHWA-HRT-20-010



In 2016, FHWA posted a Broad Agency Announcement to conduct research on potential safety improvements using the Naturalistic Driving Study (NDS) and RID information collected during the research phase of SHRP2. Phase 1 served as a "proof of concept" to determine if meaningful conclusions or countermeasures can be developed using the NDS and RID databases. Phase 2 enabled researchers to conduct more indepth analyses, leading to specific highway safety improvements.

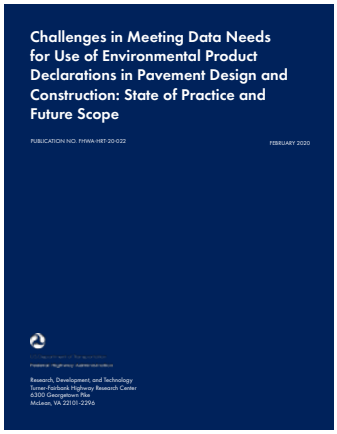
The report describes the methodology and results of one of six resulting projects to characterize normal and abnormal driving behavior in work zones. In this study, the researchers successfully used the NDS and RID databases to quantify the role of traffic management, work zone activities, and traffic conditions on driver behavior such as speed and merging. The results suggest that "nudging" drivers to comply with work zone speed limits and safe following distances would be effective at reducing the number of safety-critical events.

This report will be of interest to State and local department of transportation professionals who are responsible for managing work zones, setting guidelines and policies to implement in work zones, and developing applications and communication protocols for autonomous vehicles.

The document is available to download at *www.fhwa.dot.gov /publications/research/safety/20010/index.cfm*.

Challenges in Meeting Data Needs for Use of Environmental Product Declarations in Pavement Design and Construction: State of Practice and Future Scope

Publication Number: FHWA-HRT-20-022



The work presented in this report is part of FHWA's ongoing efforts to support the development of datasets that will provide convenient access to comprehensive, reliable, and transparent life-cycle inventories for highway construction materials. The FHWA Sustainable Pavements Program has been working toward applying life-cycle assessment (LCA) methods for evaluating environmental impacts associated with pavement design and construction and has produced a framework that addresses the fundamental goal and scope of conducting pavement LCAs. This framework has laid the foundation for the development of product category rules for pavement construction materials and the use of environmental product declarations (EPDs) in communicating the impacts of cradle-to-gate LCAs. While this framework is a step in the right direction, it has exposed various challenges associated with producing consistent product category rules and using EPDs to reliably communicate environmental impacts of pavement construction materials.

This report documents these challenges and classifies them within technical and organizational contexts. A key challenge identified was that, to improve the reliability and usefulness of EPDs as an instrument for assessing the life-cycle environmental impact of a product as part of a full pavement LCA, there is a critical need to identify and develop reliable, consistent, publicly available background datasets for upstream processes, create protocols to harmonize product category rules, and ensure the use of these consistent background datasets in future EPDs creations. To address this need, FHWA has initiated a follow-on research effort that will develop a framework to aid consistency of LCA background data and provide guidance for PCR harmonization with completion expected in late next year.

In addition, this report documents the requirements of the recently passed California Assembly Bill 262 and the experience of the California DOT as it prepares to address the challenges of adopting EPDs into practice as an implementing agency and as it prepares to pilot requiring EPDs for a wide range of pavement materials. This report concludes with suggestions to best address identified challenges and facilitate the smooth adoption of EPDs. This report is intended for State DOTs' LCA practitioners, product category rule developers, and EPD producers.

The document is available to download at *www.fhwa.dot.gov /publications/research/infrastructure/pavements/20022*.

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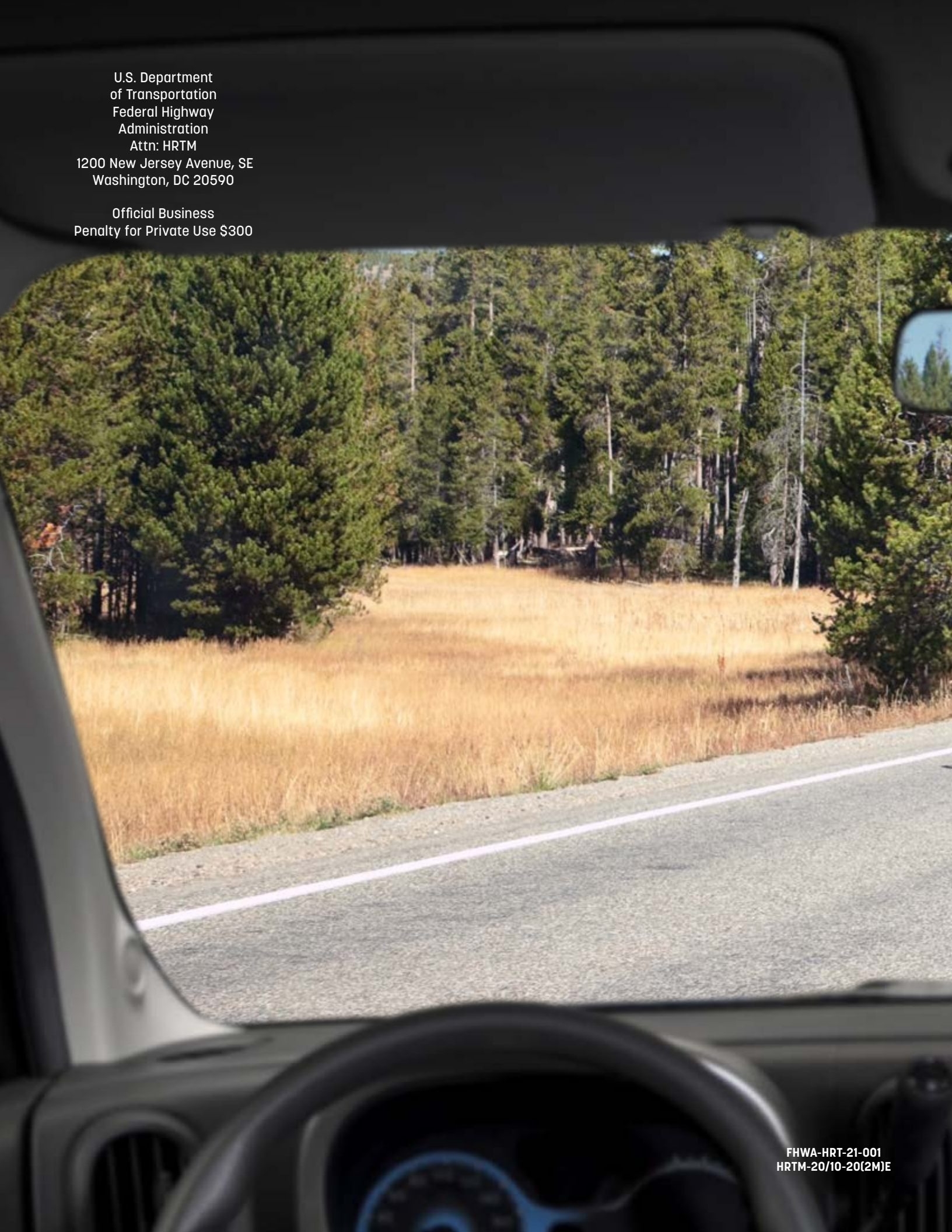

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