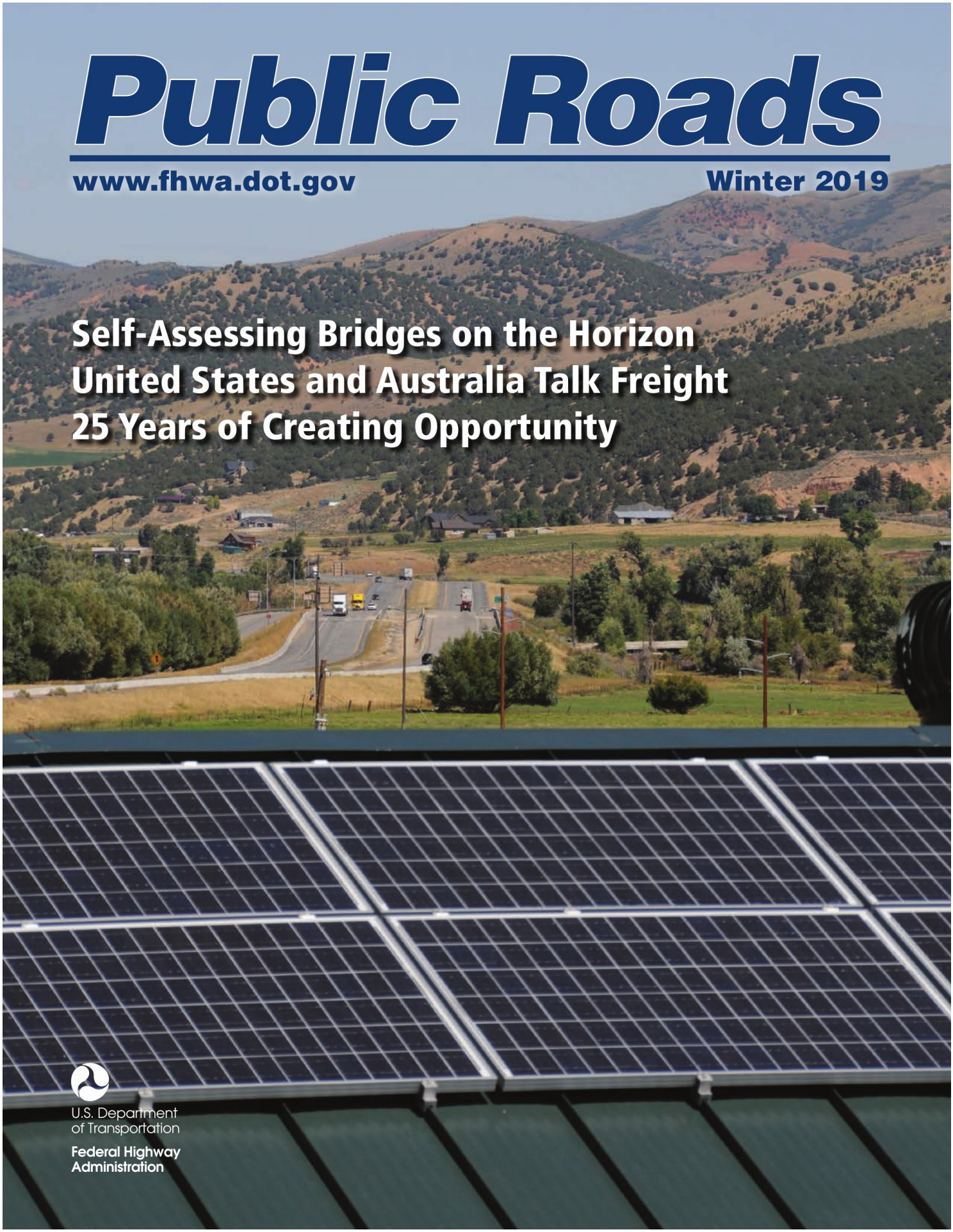
Public Roads
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Self-Assessing Bridges on the Horizon
United States and Australia Talk Freight
25 Years of Creating Opportunity
U.S. Department of Transportation
Federal Highway Administration

Public Roads

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

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Front Cover—The Utah Department of Transportation installed these rooftop solar panels on the agency's Wanship Maintenance Station on I–80. The State DOT has installed several small-scale renewable energy projects at its facilities. For more information, see "Renewable Roadsides" on page 16 in this issue of PUBLIC ROADS. *Photo: UDOT.*

Back Cover—Wyoming Department of Transportation telecommunications employees install a roadside unit on I–25 near the junction with I–80. For more information, see "Getting Connected in Wyoming" on page 20 in this issue of PUBLIC ROADS. *Photo: WYDOT.*

U.S. Department of Transportation
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Guest Editorial

Challenges and Opportunities Ahead

It is my honor to serve as the executive director of the Federal Highway Administration. Being selected for this position is the ultimate capstone to what has been an exciting and rewarding career with FHWA. I understand the critical responsibilities that come with the position, and I fully intend to carry them out to the best of my ability. I am passionate about the work we do and believe we have some of the most dedicated, talented, and professional staff in all of government.

FHWA and our partners face a number of challenges and opportunities in the coming years—expiration of the current Federal surface transportation authorization, the future of the Highway Trust Fund, rapid technological advancements, saving lives on our roadways, and development of our future transportation workforce, just to name a few. Secretary of Transportation Elaine L. Chao has defined goals for the Department in the U.S. Department of Transportation *Strategic Plan*, and FHWA Acting Administrator Brandye Hendrickson has built off that agenda with the recent issuance of the FHWA *Strategic Plan* for fiscal years 2019–2022.

The FHWA *Strategic Plan* not only states what is important to FHWA as an organization, but it also sends a message to FHWA's partners and stakeholders that we strive to deliver outstanding customer service and that we will measure our success by the success of those we serve. I am extremely excited to work toward reaching the goals outlined in these guiding documents and putting the strategic plans into action.

FHWA is not alone in this effort. Part of our future success depends on how we continue to work with and learn from our partners, public and private, here and abroad. In my previous experience working in FHWA's Office of Infrastructure, I learned firsthand how critical it is to continue to develop and deploy innovative ways to design, build, inspect, and manage roads and bridges. I also learned that no one has a monopoly on good ideas, and that many of the innovations we deploy today—and will deploy tomorrow—result from an exchange of ideas with partners.

That theme of collaboration is demonstrated in this issue of PUBLIC ROADS. For example, one article describes an information exchange between FHWA and our colleagues in Australia about freight policy, which is crucial to any nation's economic success. See "Exchanging Solutions Across the Globe" on page 4. Another article describes work by State transportation agencies to explore solar power technologies to reduce energy costs and promote energy security. FHWA supports highway renewable energy by providing resources and funding workshops where agencies can learn about efforts to implement renewable energy projects. See "Renewable Roadsides" on page 16.

In addition, the Innovation Corner article on page 2 highlights the Special Experimental Project Number 16, also known as SEP-16. The project will test and evaluate delegation of program areas to States. This project is a continuum of the risk-based stewardship and oversight approach FHWA has been pursuing for years.

I look forward to working with those of you within FHWA and also with our partners on these and other initiatives. The future is filled with challenges waiting to be turned into opportunities, and opportunities waiting to become successes.

Thomas D. Everett
Executive Director
Federal Highway Administration

INNOVATION CORNER

by Cindi Ptak

Introducing SEP-16: New Opportunity to Innovate

On September 20, 2018, the Federal Highway Administration released a *Federal Register* Notice establishing a new Special Experimental Project (SEP) that provides States with an opportunity to explore new responsibilities in the management of the Federal-aid Highway Program. A SEP is an opportunity for States to collaborate with FHWA to innovate the process and improve the delivery of the Federal-aid Highway Program.

This SEP, named SEP-16, tests the delegation of program-level responsibilities of the Federal-aid highway system to States. The term "program-level" in SEP-16 means programmatic decisions that apply generally to projects in a State and broadly affect its Federal-aid highway system. However, this excludes federally inherent functions relating to eligibility, obligation, reimbursement, authorization, and compliance.

Through existing Stewardship and Oversight Agreements between FHWA and State departments of transportation, States are already exercising project-level responsibilities for design, plans, specifications, estimates, contract awards, and inspections for projects that receive Federal funding, including those on the Interstate System. To help implement Section 1316 of the Fixing America's Surface Transportation (FAST) Act, FHWA released a *Federal Register* Notice soliciting feedback from States and other stakeholders on the possibility of additional project-level authorities. The responses indicated that States were interested in assuming program-level responsibilities.

> *"A SEP is an opportunity for States to collaborate with FHWA to innovate the process and improve the delivery of the Federal-aid Highway Program."*

"The States are asking to assume more authority and flexibility in implementing their programs, and this experiment could provide that opportunity," says Tony Furst, FHWA chief innovation officer and director of the FHWA Office of Innovative Program Delivery. "That puts SEP-16 in line not only with State interests, but also FHWA priorities. We look forward to the States' proposals."

How It Works

Based on the feedback received from the *Federal Register* Notice regarding Section 1316 of the FAST Act, FHWA anticipates that States are interested in experimenting with actions such as approval of design standards, noise policies, preventive maintenance programs, and real property acquisitions and disposals.

SEP-16 provides a three-tiered process for States that would like to explore this opportunity:

Step 1. The first step is a letter of interest detailing the specific legal authorities being requested for delegation.

Step 2. If accepted, the next step is a five-page concept paper with a narrative describing the State's proposal.

Step 3. The third step is a detailed proposal that will lead to an evaluation plan and a memorandum of understanding between FHWA and the State DOT to carry out the experiment.

FHWA, with the State, will evaluate each step and determine if the proposal can proceed to the next step.

Lessons learned from SEP-16 will inform FHWA and the States regarding what would be necessary for States to assume program-level authorities.

Past SEP Successes

SEP-16 is not the first time FHWA has asked States to experiment with new processes. The successful and still active SEP-14 was launched nearly 30 years ago. SEP-14 includes innovative contracting practices, many of which went on to be codified in Federal law. In addition, SEP-15 started in 2004 and broadened the scope of SEP-14 to include testing of public-private partnership approaches. These SEPs are still available to test and evaluate innovative practices.

"Previous SEPs have laid the groundwork for significant, lasting changes in the way we do business," says Mark Sullivan, director of the FHWA Center for Innovative Finance Support. "Approaches such as design-build and public-private partnerships were brought into our practice this way. The results of SEP-16 remain to be seen, but it opens the door to innovation."

For more information, contact Cindi Ptak at 202-366-8408 or visit https://www.federalregister.gov/documents/2018/09/20/2018-20347/new-special-experimental-project-sep-16-to-evaluate-proposals-for-delegation-of-certain-program-wide.

Cindi Ptak is the managing director of FHWA's Office of Innovative Program Delivery.

Call for Abstracts for PUBLIC ROADS

Do you have research results or a program success story to share? Are you using state-of-the-art technology or innovative methods that have had a positive effect on your program? Do you know of a good story that would be of interest to fellow highway professionals? If so, share your idea for a possible article in PUBLIC ROADS!

Promote your work while providing readers with valuable data, insights, and lessons learned.

Guidelines:

- Write a brief summary of your article idea (up to 1 page)
- Do not endorse specific products, companies, or manufacturers
- Include the primary author's name, title, and affiliation, as well as the email address, phone number, and mailing address for all authors
- Submit your abstract to PublicRoads@dot.gov with "PUBLIC ROADS Article Abstract" in the subject line

Ideas submitted by FHWA and State DOT authors preferred. Other Federal agencies, local and Tribal DOTs, field researchers and practitioners, and academia are also welcome to submit ideas but are encouraged to collaborate with FHWA or State DOTs.

For more information on requirements, submissions, and the approval and editorial processes, visit www.fhwa.dot.gov/publications/publicroads/author.cfm.

U.S. Department of Transportation
Federal Highway Administration

Exchanging Solutions Across the Globe

FHWA collaborated with colleagues in Australia on a successful information exchange primarily focused on freight policy.

by Jihan Noizet and Matthew Dorfman

"Road trains," or freight trucks with multiple trailers, are an efficient way to haul large amounts of freight across long distances in remote areas of Australia. The information exchange between FHWA and Australia's National Transport Commission has enabled both agencies to collaborate and learn from each other about policies, techniques, and solutions to challenges on a variety of freight issues and other topics. *Photo: National Transport Commission.*

The phrase "two heads are better than one" is popular for a reason. Bringing people together to tackle problems facilitates and accelerates effective solutions. When two countries face similar transportation challenges, the government agencies responsible for tackling those challenges can benefit significantly from sharing relevant information with each other. The United States and Australia are doing just that during an information exchange.

As part of its mission to improve mobility on the Nation's highways through national leadership, innovation, and program delivery, the Federal Highway Administration is responsible for implementing policies that impact interstate highways in the United States and all the vehicles that drive on them. In Australia, the National Transport Commission (NTC) works collaboratively to identify, design, and champion regulatory and operational solutions to national problems affecting land transport users across the country.

During an initial meeting in 2010, FHWA and the NTC realized that their respective countries faced similar policy, regulatory, and technical challenges in the freight transportation sector, such as truck parking, performance-based specifications, and heavy vehicle maintenance and inspection. Moreover, the United States and Australia, although located on opposite sides of the world, have many similarities. Both countries have large capitalism-based economies and are economically well-developed, with similar gross domestic product per capita. Both have Federal systems of government, with powerful States and important transportation bodies at the national levels—including FHWA and the NTC. In addition, each country is geographically large, leading to economies that rely heavily on land-based freight transportation.

After recognizing these similarities, FHWA and the NTC developed an information exchange program consisting primarily of 25 joint webinars to date. Most of the webinars have focused on freight topics. The program has proven to be mutually beneficial, but not without challenges. Participants interviewed for a final report on the program would like to see the exchange continued with an expanded focus.

The Start of a Formal Partnership

In 2009, the NTC reached out to FHWA to arrange an introductory meeting with a representative from FHWA's Office of Freight Management and Operations during the 2010 Transportation Research Board Annual Meeting. At

that meeting, FHWA and the NTC expressed interest in establishing a professional relationship and an ongoing information-sharing program. "The first meeting was invaluable," says Stephen Kern, leader of the Global Technology Exchange Team in FHWA's Office of International Programs. "It opened a gateway to information exchange for both partners."

In 2010, Nick Dimopoulos, then NTC's chief executive officer, traveled to Washington, DC, to meet with Jeff Paniati, then FHWA's executive director, to explore opportunities for mutual collaboration. They agreed the two countries could learn from each other's Federal transportation programs. The meeting concluded with a commitment by both to explore the possibilities for an ongoing exchange of information.

Following the meeting, FHWA's Office of International Programs began exploring possibilities for information and personnel exchanges with the NTC, and the two agencies settled on a webinar series. FHWA and the NTC held 25 webinars, 4 or 5 per year, between 2010 and 2015.

Selecting Webinar Topics

FHWA and the NTC collaborated to determine topics for the webinar series on an annual basis. Each agency suggested about half of the topics for the webinars. At each organization, a project representative solicited input from agency personnel. The two representatives then shared the topics with each other and selected those of greatest common interest.

"We chose topics we thought would interest both agencies, or topics in which one party possessed expertise and about which the other party was interested in learning," says Jerome Carslake, formerly the NTC-FHWA partnership coordinator at the NTC.

As developers planned the series, the two countries discovered many freight-related topics about which they could learn a lot from one another, driving the focus of the exchange. Out of 25 webinars, 21 addressed freight issues, including the environmental and technological impacts of freight. In Australia, operational, planning, investment, and enforcement-related highway issues not related to freight are frequently handled at the State level, so the main areas of activity for the NTC are freight related. In addition, personnel in FHWA's Office of Freight Management and Operations and the Federal Motor Carrier Safety Administration (FMCSA) had a strong interest in Australian freight-related topics.

The other four webinars focused on general transportation topics including two on intelligent transportation systems and two on public-private partnerships.

Benefits of the Information Exchange

The webinar series resulted in a range of benefits that made participants in both countries eager to continue the exchange.

Increased knowledge for policy discussions. Participants from both countries said that the webinars gave them a better understanding of the policy implications of each topic.

Enhanced technology transfer. Participants felt better informed about how emerging technologies were being used worldwide. "The interactive nature of the webinars provided participants with a more practical understanding of various technologies than simply reading about them in a periodical would have provided," says Neil Wong, project director at the NTC.

Formation of key contacts. The information exchanges helped participants establish key contacts in their fields in the other country. This opened the lines of communication for questions or issues that arose outside of the webinar series. For example, Tom Kearney, a senior freight specialist with FHWA's Resource Center and previously the manager

Webinar Series Topics

Overall Topic	Number of Webinars	Examples of Specific Topics
Data Collection and Analysis	2	• Measuring U.S. freight volume • Aggregating U.S. data sources to create nationwide truck performance measures
Multimodal Freight	2	• U.S. and Australian port activities • Improving freight movements near ports • Improving community impacts near ports
Road Freight Productivity Initiative	3	• Increasing the economic performance of U.S. and Australian freight industries • Improving information about the availability of U.S. truck parking • Measuring impacts on productivity from trailer/truck combinations in Australia
Road User Charging	4	• Charging operators of heavy vehicles for their use of roads • Potential Australian policy changes • Current U.S. road-use pricing and potential changes
Safety	6	• Regulating safety through maintenance and inspections • Monitoring fleet operators • Enforcing safety in a connected vehicle future • Studying driver alertness and managing driver fatigue in Australia
Strategic Policy	4	• Setting up a nationwide heavy vehicle regulator in Australia • Setting up public-private partnerships in the U.S. and Australia
Technology	3	• Approaches to emerging technologies, including intelligent transportation systems and heavy vehicle telematics
Environment	1	• Certifying environmentally efficient U.S. freight carriers using the SmartWay program

Three of the webinars focused on approaches to emerging technologies, including intelligent transportation systems and wireless communications between vehicles. *Photo: USDOT.*

of FHWA's Freight Operations Program, maintained frequent communication with the NTC as well as Transport Certification Australia, a government agency that provides services for the use of telematics and related intelligent technologies. This communication provided valuable insights for FHWA's concept of operations for virtual weigh stations.

Exposure to international experts. In several webinars, the presenters from FHWA and the NTC brought in external experts to discuss the topics, familiarizing the participants from the other country with experts from a range of fields and opening opportunities for additional collaboration. For example, organizers brought in U.S. and Australian industry representatives to discuss port coordination efforts, which ultimately resulted in U.S. speaker participation in a series of invitation-only roundtable forums, hosted by the NTC, to promote cohesion across port supply chains and improve productivity and practice.

Proof of policy success. The information exchange series gave participants examples of policy successes in the other country that could be shared with relevant groups in their own country, sometimes leading to progress on difficult policy issues. One Australian participant said that an FHWA presentation helped persuade a reluctant stakeholder group of the value of a proposed policy: "Three sentences from [FHWA] experts were as good as 3 months of persuasion."

Critique by foreign experts. In some webinars, the open exchange of ideas that occurred after the presentation enabled participants to get feedback from a foreign expert. "Foreign experts were able to review a given situation more objectively than a domestic expert could because the foreign experts were not as close to the problem," says Kern.

Challenges with the Information Exchange

Despite the successes of the information exchange, organizers did encounter some challenges. Participants sometimes faced difficulties in understanding policy or in determining how to apply lessons learned from one country to the other because of the differences between the two countries, particularly in governance and the structure of nongovernmental organizations.

In general, Australian States are more politically powerful than U.S. States, especially regarding transportation. There are few policy levers available to the Australian Federal Government to coordinate State transportation activity. In contrast, the U.S. Highway Trust Fund and the various impacts of the U.S. Constitution's Interstate Commerce Clause give FHWA a stronger coordinating role among States. Similarly, Australia has several nongovernmental national and State-based organizations that represent the heavy vehicle industry, while in the United States, most interstate truck-

Long-haul freight truck traffic in the United States is concentrated on major routes connecting population centers, ports, border crossings, and other major hubs of activity. Examining travel patterns is an important step for a variety of freight-based initiatives, including performance measures, parking availability, community and environmental impacts, and more. *Source: USDOT.*

ing interests are represented by the American Trucking Associations. Despite these differences, the organizers and participants felt that the benefits of increased knowledge and new perspectives provided by the webinars outweighed the challenges.

Webinar organizers also faced a challenge in articulating the benefits of a given webinar in advance. Both agencies wanted to understand how they would benefit from each of the webinars before the webinars occurred. However, because webinar participants often learned "unknown unknowns"—facts that they did not realize they did not know—the organizers found it difficult or impossible to articulate all potential benefits of a given webinar in advance.

Finally, logistics posed a challenge. Because of the various time zones, webinars were mostly in the evening in the United States, corresponding to the morning of the following day in Australia. Holding webinars after the normal workday was not ideal for U.S. participants, but this was the best solution to the challenge. In addition, the technology used, such as dial-in lines and other webinar tools, did not always work as expected. Improving telepresence technology should mitigate this issue in the future.

The Future of the Exchange

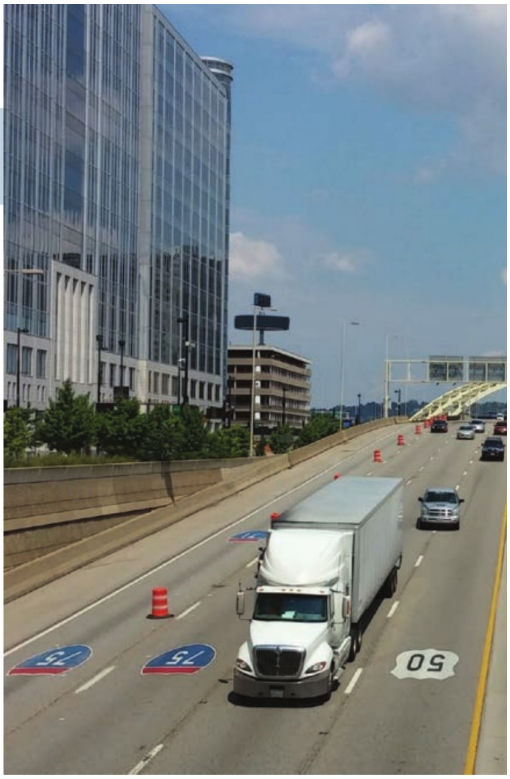
In preparing a final synthesis report about the exchange, FHWA interviewed organizers and participants. Citing the benefits and minimal cost of the program—typically a small number of person-hours in preparation for each webinar and the cost of the telepresence service—the interviewed participants agreed that the program should be continued. However, many recommended expanding the topics covered to include more webinars on infrastructure for connected and autonomous vehicles, revenue generation, and alternative finance. Additional freight topics that participants would like to see covered include developments in truck parking, vehicle platooning, and electronic logging devices.

Discussions with information exchange participants yielded three general recommendations to improve the information exchange. First, the future webinar series should be planned with benefits to each country in mind. Webinar topics should be determined each year, and for each potential topic, organizers and personnel suggesting the topic should more explicitly articulate the benefits to both countries. To support this, both FHWA and the NTC should list their perceived benefits independently. Once the topics are chosen, the listed benefits for each selected topic should be reviewed and kept in mind during the preparation for each webinar, a step which should help ensure that the benefits are realized.

Second, if topics are selected for inclusion in the webinar series that may be of interest beyond FHWA and the NTC, the organizers should invite additional audiences. Several of the initial 25 webinars included additional agencies and private-sector partners beyond FHWA and the NTC, both as presenters and participants. These webinars were successful, and the organizers should explore the potential for hosting similar multigroup webinars in the future.

Finally, FHWA and the NTC should formalize the webinar selection process. The approach should have a specific written structure. Formalizing the webinar selection process will ensure that input from the broadest range of possible sources is considered, the potential benefits from each webinar are used to select the most beneficial webinar topics, and the greatest number of beneficiary groups are included as participants in the webinars.

In addition to the webinar improvements, discussions with information exchange participants generated one more key suggestion: hold in-person meetings and explore the possibility of personnel exchanges. Holding sessions with several of the primary participants present in person may lead to more effective exchanges of information and create greater trust and understanding among the participants. Supporting brief personnel exchanges, in which a representative from one country travels to the other country and takes on the duties of an employee of the other organization for a short time, could help both participants appreciate the organizational and cultural context of the information shared in the exchange.



Some of the webinars discussed the challenges of freight movement through urban areas. *Photo: FHWA.*

Jihan Noizet is a transportation specialist with the FHWA Office of International Programs and oversees the coordination and implementation of cooperative program activities between FHWA and its foreign counterparts. She holds a bachelor's of business administration from the University of North Texas, and a master's of business administration from the University of Texas at Dallas.

Matthew Dorfman is a partner at D'Artagnan Consulting, LLP. He leads technical development efforts for an ongoing Road Usage Charge pilot in Washington State, and was project manager for the California Department of Transportation's Road Charge Pilot Program. He has a master's degree in technology and policy from the Massachusetts Institute of Technology.

For more information, see https://international.fhwa.dot.gov/pubs/pl18009/fhwapl18009.pdf or contact Jihan Noizet at jihan.noizet@dot.gov or 202-366-1153.

Recruiting Tomorrow's Workforce

by Joyce Gottlieb and Will McClure

FHWA's National Summer Transportation Institute celebrates 25 years of introducing students to college life and sparking their interest in careers in transportation.

The transportation industry faces a significant gap between the number of skilled positions needed in the workforce and the number of people qualified to fill those positions. The projected annual job openings in the transportation field through 2022 are about 68 percent greater than the number of people completing transportation-related education and training programs, according to *Strengthening Skills Training and Career Pathways Across the Transportation Industry*, a joint report from the U.S. Departments of Transportation, Education, and Labor. Without enough qualified workers, the industry grapples with a growing challenge to develop, operate, and maintain a safe and efficient transportation system.

One way the Federal Highway Administration is working to narrow the workforce gap is by encouraging young people to explore the opportunities awaiting them in transportation. Many middle and high school students are unaware that a transportation career can involve a variety of disciplines—from engineering to planning and design to safety and supply chain management. Conducted in partnership with State departments of transportation and academic institutions, the National Summer Transportation Institute (NSTI) is an FHWA program that expands the awareness of career opportunities in transportation and helps address future needs for a capable and diverse workforce.

As part of FHWA's National Summer Transportation Institute, middle and high school students get hands-on experience to learn about careers in transportation. Here, students at the Idaho State University NSTI conduct stress tests on model bridges they designed and built. *Photo: Professor Bruce Savage, Idaho State University.*

NSTI participants at Idaho State University learn about hydraulics during a hands-on exercise. *Photo: Professor Bruce Savage, Idaho State University.*

In 2018, NSTI celebrated 25 years of educating students about transportation and piquing their interest in college-level studies and career opportunities in the field.

Administered by FHWA's Center for Transportation Workforce Development, NSTI promotes science, technology, engineering, and math (STEM) disciplines among middle and high school students and encourages them to pursue transportation-related studies at the college and university level. Open to middle and high school students throughout the United States and its territories, NSTI enables teenagers to experience campus life and get a preview of transportation-related studies at accredited colleges and universities. All are welcome to apply, with a focus on underserved students, including minorities, women, socially and economically disadvantaged individuals, at-risk youth, and students with disabilities.

Introducing Transportation Opportunities

Daniel Davalos knew little about the transportation field, but he was intrigued when his high school engineering teacher distributed flyers on NSTI because it offered hands-on experience in STEM.

"I applied to this program because it would help me focus my education and career decisions in the STEM disciplines," he says.

In addition to inspiring Davalos to study electrical engineering at California State University, Los Angeles, the NSTI session he attended in 2014 gave him insight into the types of careers people could have in transportation. As a result, he says, "I am planning to use my knowledge in electrical engineering in the transportation industry."

Over the years, NSTI has benefited more than 25,000 students. In 2017, 1,446 students, including 21 with disabilities, attended programs at 62 host sites in 48 States.

To broaden access to the NSTI experience, FHWA instituted an exchange program in 2012 for students living in U.S. territories. The pilot program enabled four students to travel to the U.S. mainland to stay on a college campus and participate in a session. By 2018, about 40 students from U.S. territories had attended NSTI sessions, an average of 8 to 10 students per year.

Each year, State departments of transportation ask accredited colleges and universities (potential NSTI host sites) to develop proposals for NSTI programs on their campuses that meet FHWA's curriculum guidelines. State DOTs recommend one or more applications from potential NSTI host sites to their State's FHWA division, which reviews the applications and provides feedback and assistance on the proposed programs.

Providing Hands-On Experience

A typical NSTI program lasts 2 to 4 weeks. Host institutions offer day or residential programs that include room and board for students. Each institution targets its program to students in either high school or middle school. High school pro-grams emphasize activities to improve STEM skills, prepare participants for post-secondary education, and encourage them to pursue transportation-related careers. Middle school programs focus on career exploration.

Designed to provide a stimulating introduction to the transportation industry and career opportunities, typical NSTI programs feature exposure to land, air, and water transportation modes, as well as safety. The curriculum includes an introduction to each transportation mode taught by college or university instructors, presentations from industry professionals, and field trips to transportation and transit facilities and government agencies. Students also learn from hands-on activities, such as laboratory exercises, computer programming tasks, and competitions

Some NSTI host colleges send students to the National Flight Academy, where they spend a week in an immersive learning experience aboard the world's largest simulated aircraft carrier. "Fist of the Fleet" team members attended the academy during NSTI week in summer 2017. *Photo: National Flight Academy.*

to design bridges, gliders, solar cars, or mass transit projects.

Land transportation topics included in a typical program include highway design, transportation planning, traffic signal timing, transportation logistics, and public transit. Water transportation covers topics such as deep sea freight and passenger transportation, intercoastal waterways, towing and tugboat services, and marine cargo handling. Air transportation focuses on flight theories, aircraft performance, flight instruments, and air navigation. Safety is an integral part of the curriculum, including safe transportation infrastructure; improving safety and communication; analyzing and forecasting safety trends; and pedestrian, bicycle, vehicle, and air travel safety.

Programs also introduce methods and activities that improve study habits, promote academic achievement, and foster self-awareness. Topics include time management, critical thinking, problem solving, research techniques, and internet and library use, as well as preparation for standardized college admission tests. Students learn teamwork and sportsmanship through sports and recreation activities.

Partnership Takes Flight

Some host institutions partner with the National Flight Academy in Pensacola, FL, which offers an immersive program to inspire students to pursue STEM studies and careers. At the conclusion of their campus programs, these host institutions select students to attend a weeklong course at the academy, where they live in a simulated aircraft carrier environment and get hands-on experience learning about flight control, aircraft safety, piloting, and other technical operations associated with aviation.

Each day, academy students participate in "missions" that challenge their mental agility, preparedness, and communication skills while demonstrating the value of teamwork and goal completion. Through simulator experience and role play, students learn firsthand how those in naval aviation respond to real-life situations and emergencies. At the end of the week, students participate in a graduation ceremony to celebrate their accomplishments.

Student Perspectives On NSTI

Many former participants in NSTI programs consider their experience as key to their decision to pursue STEM-related studies in college and apply their education in the transportation and engineering fields. Many also express appreciation for the opportunity to get a taste of life on a college campus.

Dr. Makoloa Abdullah attended an NSTI program in his youth to learn about the STEM fields. He is now president of Virginia State University, where he hosts a 4-week residential NSTI program for students in grades 9 through 12. *Photo: Virginia State University.*

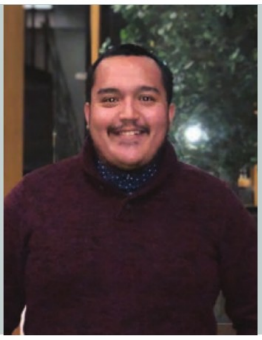
Dr. Makoloa Abdullah. Dr. Abdullah, Virginia State University president, was a junior in high school when his mother told him about the NSTI program at the University of Illinois at Chicago. "She thought it was a program I should be a part of. We all know mothers know best," he says.

"I applied because I thought it would be wonderful to have the experience of staying on a college campus while still being a high school student. It provided me with the opportunity to spread my wings," Abdullah says. "Most importantly, I had a strong interest in the STEM field, particularly in engineering."

After interning the following summer at the Illinois Department of Transportation, Abdullah earned a bachelor's degree in civil engineering from Howard University and master's and doctorate degrees in civil engineering from Northwestern University. Early in his career, he worked at a civil engineering firm in Chicago. Later, he served as a college professor, dean of engineering, and university provost.

"Throughout my career, I have always wanted to play an integral part in educating the next generation of global leaders," Abdullah says.

Samuel Bethea, Jr.'s NSTI experience led to a major in transportation/logistics at North Carolina Agricultural and Technical State University and a career in supply chain management. *Photo: Samuel Bethea.*



Juan Alonso switched his education plans from mechanical to civil engineering at the University of California, Irvine, after attending an NSTI program. His interest is road and bridge design. *Photo: Juan Alonso.*

In 2016, he became president of Virginia State University, which hosts a Summer Transportation Institute to encourage students to take advantage of transportation career opportunities.

"When individuals are equipped with the necessary tools and skill sets and possess the willingness to do the work, they will have the opportunity to make a difference not only in their life but also in the lives of individuals in their communities and the world," Abdullah says.

Samuel Bethea Jr. Bethea, a demand forecast analyst for an apparel company in Greensboro, NC, participated in an NSTI program at North Carolina Agricultural and Technical State University (N.C. A&T State University) in 2004. He was familiar with the NSTI program because his sister, Lynnia Bethea, attended in 1998 and later graduated from N.C. A&T State University with a transportation/logistics degree.

"I applied to the NSTI program to gain a better understanding of the transportation field and the career opportunities that were offered," Bethea says. "It was after I attended the NSTI program that I decided to attend N.C. A&T State University and major in transportation/logistics."

Bethea applies his transportation, logistics and supply chain management background as a member of his company's mass marketing team, working with the merchandising, operations, and sales teams to develop rolling forecasts for national retail accounts so that products can be transported in an efficient, cost-effective way. "It is a field that is growing exponentially, and companies now realize the importance of acquiring strong talent as markets across the board become more global," he says.

Juan Alonso. Alonso participated in the NSTI program in 2013 after learning about it from his high school's Mathematics, Engineering, Science Achievement program and hearing positive reviews from a friend who had attended the summer before. Alonso did not know anyone who worked in transportation, but he was interested in the Los Angeles County Metropolitan Transportation Authority and its transit-related construction projects. "At the time, I was interested in being a mechanical engineer," he says. "After the program, my heart was set on civil engineering."

Alonso earned a bachelor's degree in structural civil engineering from the University of California, Irvine, and interned with an engineering firm in Los Angeles in 2018, assisting project engineers with roadway and bridge design. "Follow your passion and the opportunities will [come] when you least expect them," he says.

Expanding the Transportation Workforce

NSTI is a program with a quarter century of success in encouraging middle and high school students to consider transportation-related studies at the college and university level. By partnering with State DOTs and colleges and universities on NSTI programs, FHWA enhances awareness among youths of what they can achieve through education.

"It is important now more than ever that we as a society expose our young people to the multitude of careers and resources available to ensure they will become our next generation of engineers, educators, scholars, technologists, scientists, and mathematicians," says Abdullah.

By fostering early interest in transportation, NSTI creates a pathway to FHWA's post-secondary education programs to expand a qualified workforce. Other FHWA resources help students continue on their learning journey. The Dwight David Eisenhower Transportation Fellowship Program awards fellowships to students pursuing transportation-related degrees. The Summer Transportation Internship Program for Diverse Groups provides college and university students—with a focus on women, persons with disabilities, and historically underrepresented members of diverse groups—with on-the-job experience while working on transportation-related topics.

"The NSTI program plays an important role in cultivating interest and expertise that will lead to today's students pursuing tomorrow's transportation careers," says Virginia Tsu, M.Ed., director of FHWA's Center for Transportation Workforce Development. "It endeavors to address future transportation workforce needs by ensuring that the transportation industry has a workforce that is expertly trained, capable, and diverse."

Joyce Gottlieb is the NSTI program manager with the FHWA Center for Transportation Workforce Development. Gottlieb has a master's degree in education and human development from The George Washington University and a bachelor's degree in multidisciplinary disciplines from Mercy College.

Will McClure is the program manager for civil rights with the FHWA California Division, where he serves as the division's field representative on matters pertaining to civil rights and equal opportunity. A retired U.S. Army first sergeant, McClure earned bachelor's and master's degrees in business administration from Touro University.

For more information on NSTI programs, contact your State transportation department's Civil Rights Division or State FHWA Division office.

Toward Self-Diagnosing Bridges

by Fred Faridazar

Wireless, self-powered sensors may be the key to continuously monitoring infrastructure. FHWA-sponsored research is aiming to advance the technology.

This graduate student is installing a prototype of the piezo-floating-gate (PFG) sensor on the Mackinac Bridge in Michigan. *Photo: Nizar Lajnef, Michigan State University.*

The ability to monitor the condition of bridges and other civil infrastructure systems is of primary interest to all infrastructure owners and operators. These stakeholders need to have precise and accurate information on infrastructure conditions before making decisions such as maintenance strategies or investments.

Research sponsored by the Federal Highway Administration is paving the way for wireless, self-powered sensors capable of continuously monitoring infrastructure. The development of advanced structural monitoring methods can facilitate the early detection of possible structural deterioration, with the goal to extend the lifespan of structures. Timely information gathered from such technologies will undoubtedly help transportation agencies in the corrective and urgent decisionmaking process.

Currently, state-of-the-art technologies and solutions evaluate the condition of a structure at a given interval, providing only a snapshot at the time when the measurements are taken. Results from this method are highly influenced by environmental conditions, such as ambient temperature, at the time of assessment. There are many factors that lead to bridge failures including natural hazards, crashes, overloading,

and deterioration and fatigue cracking (which could result in collapse if left unchecked and could cause bridge closures). The focus of this FHWA research is to develop a unique sensor for monitoring fatigue cracks in steel bridges. These factors justify the pressing need for an autonomous, continuous, and long-term monitoring system.

One prospective solution to structural monitoring concerns is piezo-floating-gate (PFG)-based sensing technology. The sensors operate without batteries and are small enough to be embedded inside concrete or attached to steel structures. While the sensors are small, their potential to provide continuous usable data is substantial.

Challenges to Implementation

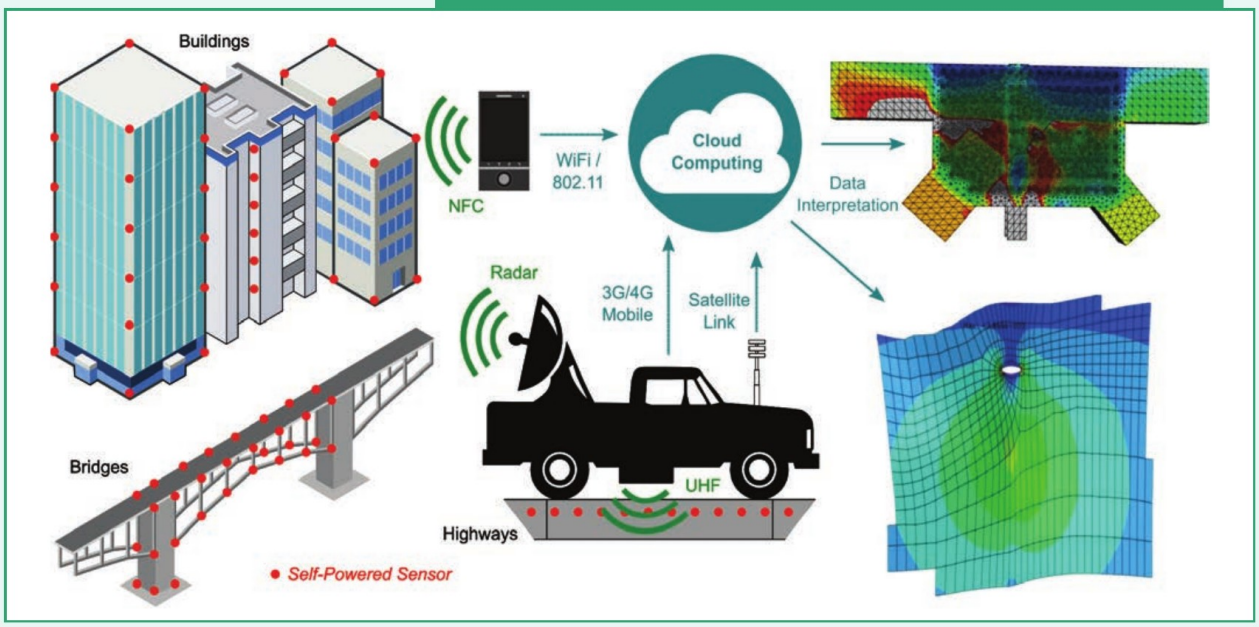
A number of challenges have hampered the practical application of structural health monitoring. Among the most serious is the infeasibility of using a sufficient number of conventional sensors (such as strain gauges and high enough accelerometers) to provide a high-enough spatial resolution to capture response variations that may be precursors to serious structural damage. The collection of measurements from the target structures needs not only the sensors themselves, but also an instrumentation network to collect and transmit the data for subsequent analysis. In addition, the need exists for robust energy sources to drive the sensors and associated data acquisition network.

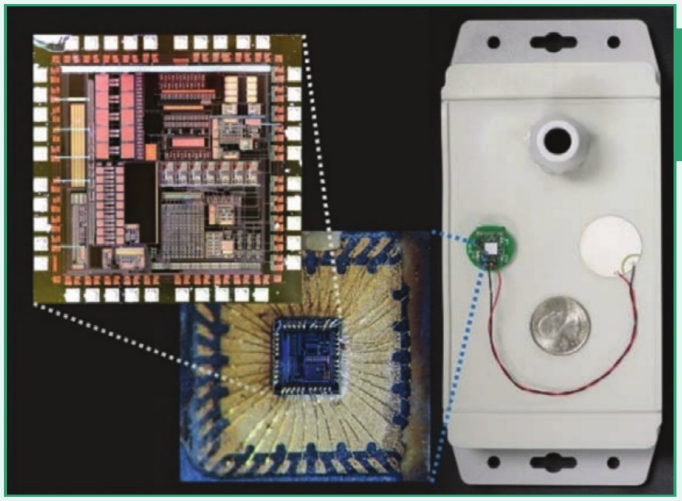
The development of wireless networks has eliminated the need for performing the arduous task of stringing connecting cables. Ensuring an adequate energy source to power a sensor network for long-term, autonomous, and continuous monitoring remains a challenge. Embedded and long-term operational requirements preclude the use of batteries, whereas the small sensor volume severely limits the energy storage capacity of energy harvesting devices. Currently, a wide gap exists between the energy that can be scavenged from real-world structures and the energy density required for sensing, computing, and communication. However, this impediment has been partially resolved by research sponsored by FHWA on self-powered sensors at Michigan State University in East Lansing, MI, and Washington University in St. Louis, MO.

The recent research has yielded novel self-powered sensor technology that is capable of achieving picowatt power dissipation, which is two orders of magnitude lower than any other commercially available sensor technology. The ultralow power computation and data-logging technology has been shown to be capable of autonomous, long-term monitoring of dynamic loading events.

Prototype systems have been developed and tested as part of FHWA-funded projects (DTFH61-08-C-00015 Smart Pavement Monitoring System and DTFH61-13-H-00009 Ultra-low Power Wireless Sensing for Multimetric Self-Powered Monitoring of Bridge Components and Highway Infrastructure). The sensing technology offers several features that are not available in other traditional methods of structural health monitoring including: (1) low power requirements (less than 80 nanowatts of power consumption), (2) self-powered continuous sensing (no batteries required), (3) possibility of deployment in dense networks

An array of self-powered sensors embedded in infrastructure (for example, buildings, bridges, and highways) can continuously monitor the condition of the infrastructure. Currently, the data from the sensors are uploaded wirelessly by radio-frequency identification (RFID) readers from moving vehicles or handheld devices. Several State DOTs have expressed a need to further increase the system capability in future research by uploading data to the cloud via mobile phone, tablet, or laptop computer with internet access for analyses and interpretation as illustrated here. *Source: Nizar Lajnef, Michigan State University.*





Micrograph of the sensor circuit and a prototype sensor packaged in a protective box to sustain the harsh environment at the Mackinac Bridge. *Photo: Nizar Lajnef, Michigan State University.*

Prototypes of the PFG sensor and protective box were deployed on the Mackinac Bridge, shown here. Engineers and the university research teams installed the sensors on the cross beams in the main suspended span. *Photo: Mackinac Bridge Authority.*

(sensor networks with a very large number of sensors to ensure no gaps in coverage) given the small size of the sensors and the fact that they do not rely on batteries, (4) autonomous computation and nonvolatile storage of sensing variables, and (5) wireless communication.

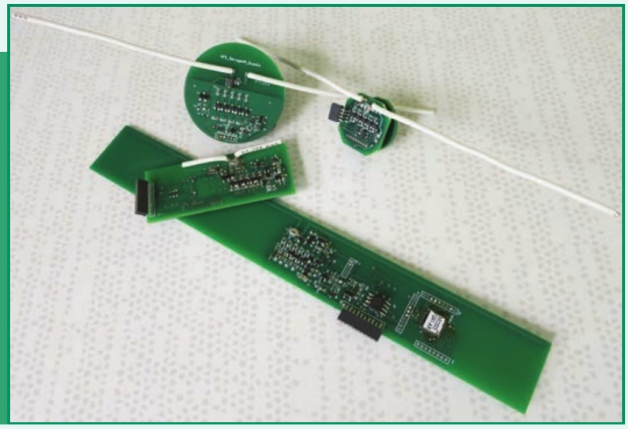
"There is huge potential and benefit for sensors like these on structures beyond the Mackinac Bridge, and we're excited these prototypes are being tested here," says Executive Secretary Bob Sweeney with the Mackinac Bridge Authority in Michigan. "We meticulously maintain and inspect the bridge each year, and sensors like these will complement our efforts, giving us even more information on the bridge's condition to help keep it well-maintained and safe for many years to come."

What Makes this Technology Unique?

All sensor technologies developed to date are based on a similar set of components, or building blocks. Typically, a system consists of a transducer to generate the signal of interest, converters and regulators, and a data storage or transfer link. These components require a constant source of power. As a result, all commercially viable sensors require either solar or battery power. Neither option is practical for monitoring highway infrastructure because it requires thousands of sensors to properly monitor the desired responses.

For pavements, sensors need to be embedded beneath the material to be able to detect hidden cracks, thus eliminating the possibility of using batteries or solar power. For bridges, a large number of sensors is needed for an effective high-density monitoring network. However, periodic replacement of batteries is unfeasible, and the expense of solar power technology is cost-prohibitive. Furthermore, in the context of civil structures systems, it is important to be able to capture each loading event. Structures are infrequently subjected to significant loading. During the times between significant loading cycles, it is possible that the sensor would experience periods of inactivity. It is a challenge to handle these "blackout" periods because commercially available solutions using any onboard battery or ultracapacitor might lose their charge between intermittent loading cycles. The same logic can explain the need for using nonvolatile memory storage because any volatile memory storage would be lost during power blackouts.

To overcome these challenges, FHWA-sponsored research has led to the invention of a new way of capturing, computing, and storing the strain and acceleration signals generated on a civil or mechanical structure. The technology is called piezo-floating-gate, or PFG, sensing. "Piezo-" is borrowed from the piezoelectric transducers used in the technology. These materials are capable of converting mechanical



Sensor prototypes are manufactured in different sizes and shapes adapted for multiple applications including building, bridge, and pavement monitoring. *Photo: Mackinac Bridge Authority.*

These packaged PFG sensor prototypes are being installed at the accelerated pavement testing facility at The French Institute of Science and Technology for Transport, Spatial Planning, Development and Networks (IFSTTAR) in Nantes, France. The sensors were installed by the Michigan State University and Washington University research team in collaboration with researchers at IFSTTAR. *Photo: Nizar Lajnef, Michigan State University.*

energy, such as vibrations, into electrical energy. The generated electrical signals, which are directly proportional to the mechanical excitation, are also used to power all electronics in the sensing system.

The novel design enables the sensor to derive its power from the same signal it is sensing. The sensor electronics act like a large container of electrons. Every time the structure is loaded, for example when a truck passes over a bridge or over pavement, the piezoelectric material will send a signal that will shake the container. Because of that energy, some electrons will get thrown away into a smaller container that is isolated and does not get shaken (hence the name "floating"). The process is called hot-electron injection. The smaller container acts like permanent memory because the electrons in it are permanently trapped. Counting the number of trapped electrons will convey the number of times the system was shaken and the intensity of those trembles, which is directly related to the number and amplitude of the external loading (for example, a passing truck). This concept implements a power-efficient sensing system, and alleviates the need for a power source and all other interface electronics required in a typical sensor.

The Data Challenge

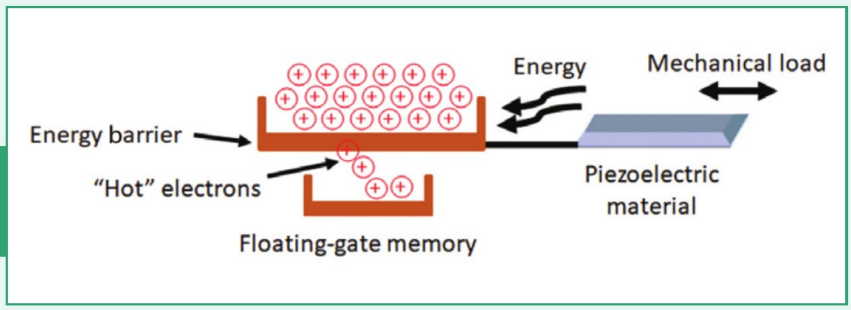
Another important challenge in monitoring the health of a large structure is to make sense out of the large amount of data generated by the sensors. To address this challenge, each sensor has a series of memory-cells, or gates, that are placed adjacent to the computational circuits. The information delivered by the piezoelectric transducer is stored in these gates. The gates record the duration of strain/voltage events when the amplitudes of the input signals, generated by the piezoelectric transducer, exceed certain predetermined thresholds. The output of the sensor is presented in the form of a histogram, in which each gate denotes the cumulative time of the events at a specific, predetermined strain level. The self-sustained sensing systems use the sensor output to relate the variation rate of strain distributions to the rate of damage.

The new type of data requires specific techniques for data interpretation. The research team at Michigan State University has developed advanced software and tools for bridge operators and State departments of transportation to understand the data. The software will automatically interpret the data and then synthesize and present them in a simplified way to users to assist them when making maintenance decisions.

The successful development and implementation of this multimetric sensing system and the data interpretation procedures could dramatically transform the economics of bridge and road preservation, and ultimately improve infrastructure serviceability.

Fred Faridazar is a highway research engineer with the FHWA Office of Infrastructure Research and Development at the Turner-Fairbank Highway Research Center, a position he has held since 2000. He has acquired research experience related to structures, pavements, concrete materials to complement the bridge design and construction experience acquired through his prior positions with the FHWA Florida Division Office and FHWA's Office of Federal Lands Highway.

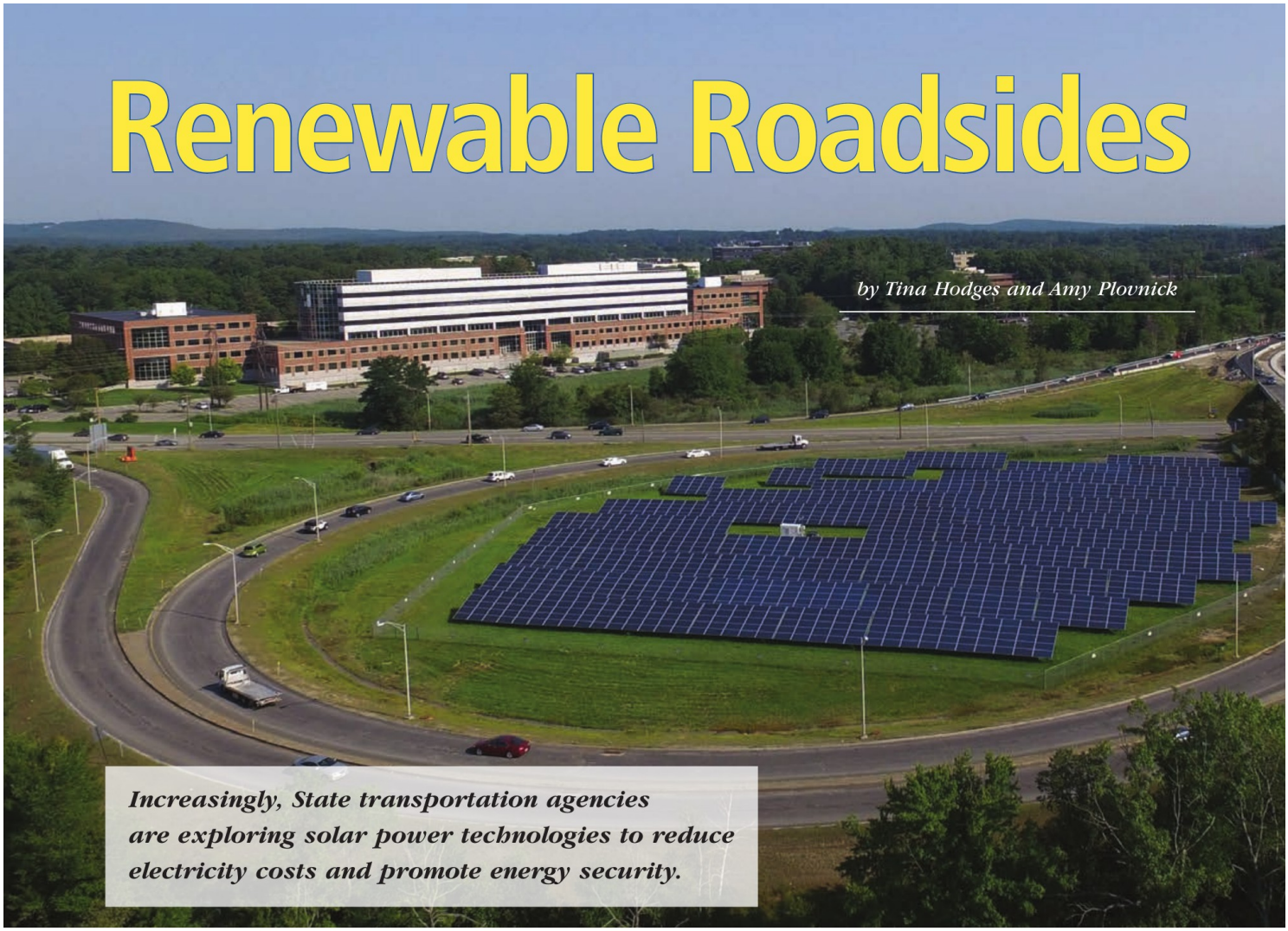
For more information, see www.fhwa.dot.gov/research/tfhrc or contact Fred Faridazar at 202-493-3076 or Fred.Faridazar@dot.gov.



This illustration demonstrates the PFG principle. *Source: Nizar Lajnef, Michigan State University.*

Renewable Roadsides

by Tina Hodges and Amy Plovnick



Increasingly, State transportation agencies are exploring solar power technologies to reduce electricity costs and promote energy security.

State highway departments have many responsibilities, from fostering roadway safety to plowing and mowing roadsides to implementing major repair and replacement projects. Often overlooked is the fact that these agencies require significant electricity to power their operations. For example, roadway signs and lights, maintenance buildings, rest areas, and other facilities all require electricity.

After considering costs and benefits, some State departments of transportation have chosen to meet a portion of their electricity needs by installing solar energy projects in highway rights-of-way (ROW) and at other State DOT facilities. Some agencies are finding that pursuing renewable energy generation not only benefits the environment but can also save money on energy costs.

The price of solar photovoltaic systems dropped more than 60 percent between 2010 and 2017. In many cases, solar power is cost-competitive or even cheaper than fossil fuel sources of electricity. Twenty-nine percent of all new electricity-generating capacity came from solar installations in 2017, second only to natural gas (46 percent), and slightly ahead of wind (22 percent).

As renewable energy technologies have matured, the business models serving public entities have expanded as well. Many State and local government agencies are able to work with private-sector partners to install renewable energy at no upfront cost to them and save money on their electricity use, all while helping the environment and serving the public.

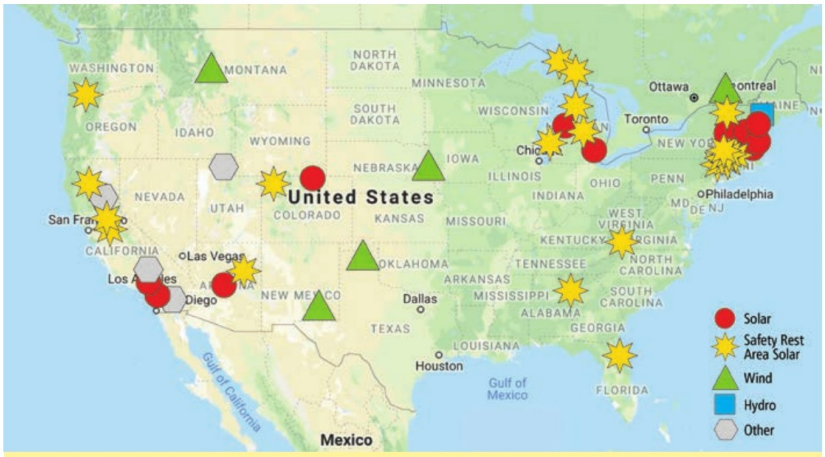
The Federal Highway Administration supports highway renewable energy through developing resources and funding workshops where agencies can learn about efforts to implement renewable energy projects. By sharing their challenges and successes with their peers, State DOTs are learning from each other, and the share of transportation agencies that are pursuing renewable energy continues to grow.

"We're thrilled to see [State] DOTs innovating by generating clean, renewable energy on their properties where feasible," says Michael Culp, team leader of the FHWA Sustainable Transportation and Resilience Team. "This gives us an opportunity to help them save money and also protect the natural environment."

Benefits to State DOTs

As interest in renewable energy projects increases, staff at State transportation departments across the country are championing these efforts. They are navigating the complicated world of electricity production and regulation, and ensuring that these renewable energy projects meet their departments' missions and requirements.

The Massachusetts Department of Transportation installed these solar panels in the right-of-way at Exit 13 North on the Massachusetts Turnpike (I–90) in Framingham. The State DOT has installed several solar projects at multiple sites. *Photo: MassDOT.*



States across the country are using renewable energy sources in the highway ROW. This map shows a snapshot of highway renewable energy projects known by FHWA. *Source: FHWA.*

State DOTs have recognized many potential benefits of implementing solar energy projects.

Identifying secondary purposes for ROW. In many cases, the highway ROW owned by State DOTs is close to electrical loads, free from development, and already disturbed, making it an attractive location for solar power.

Saving money on electricity costs. Installing solar power can help State DOTs offset their electricity costs. The electricity produced can directly power department assets and facilities, such as roadside lighting or maintenance buildings. Depending on State policies, the electricity produced may also be sent to the electrical grid and used to offset the DOT's electricity bill through net metering.

Producing clean energy and promoting energy security. Compared to burning fossil fuels, obtaining electricity from solar or wind reduces harmful pollutants such as mercury, nitrous oxides, and heat-trapping carbon dioxide. Solar energy also helps DOTs meet State environmental goals and requirements, and promotes energy security by diversifying energy generation and delivery methods.

Fostering green jobs. Highway solar projects help promote the local green job market and the Nation's growing clean energy economy. Nationwide, the solar workforce increased by 168 percent in 7 years, from about 93,000 jobs in 2010 to more than 250,000 jobs in 2017.

State DOT Experiences

Most State DOTs that have installed renewable energy technologies have used solar power, either ground-mounted solar panels along the ROW and at rest areas or rooftop solar on carports, maintenance buildings, rest areas, or other facilities. A few State DOTs have installed small-scale, pilot wind turbines at rest areas. As technologies advance, more opportunities may arise to incorporate additional types of renewable energy beyond pilot projects, such as solar roadway surfaces, photovoltaic noise barriers, tidal turbines under bridges, or micro-wind turbines.

Each highway renewable energy project has a unique context, and State DOTs interested in pursuing this option must consider applicable State and Federal requirements—for example, whether the site is located on an interstate highway (which would introduce operational and safety issues), uses for the power, and project goals.

As they explore the possibilities, State DOTs are learning from their peers. Early adopters of ROW solar and State DOTs that are currently pursuing renewables provide lessons based on their experiences for those considering options for the future.

The Oregon DOT installed this nearly 7,000-panel solar array at the French Prairie Rest Area on I–5 in 2012. *Photo: Craig Strobeck, Advanced Energy Systems and ODOT.*

These solar panels are located at the Framingham Service Plaza on I–90 in Massachusetts. *Photo: Volpe Center.*

Oregon: An Early Adopter

In 2007, Oregon Governor Ted Kulongoski directed State agencies to meet 100 percent of their electricity needs with renewable energy by 2025. Motivated by this challenge, the Oregon Department of Transportation (ODOT) began looking for renewable energy opportunities and implemented the first large-scale solar roadway projects in the United States as demonstration projects. In 2008, ODOT completed a 104-kilowatt system with 594 solar panels located at the interchange of I–5 and I–205 near Portland.

In 2012, ODOT implemented a much larger project at the French Prairie Rest Area on I–5 in Clackamas County. This 1.75-megawatt project includes nearly 7,000 solar panels and sits on a 7-acre ODOT property at the rest area. ODOT did not need such a large property for the rest area, so it was able to use a portion of it for the solar array. The solar array produces approximately 1.97 million kilowatt-hours of renewable energy annually. ODOT pursued both projects as public-private partnerships with Portland General Electric.

Massachusetts: Solar Power at Multiple Sites

The Massachusetts Department of Transportation (MassDOT) began exploring the potential of ROW solar in 2012 by identifying approximately 60 sites that could be used for solar power generation and vetting the most promising sites within the agency. MassDOT awarded a contract in 2014 for the development of 6 megawatts of ROW solar projects across multiple sites. The contractor has completed projects at eight sites totaling 4.3 megawatts; seven sites (3.75 megawatts) are located within the ROW, and another 550 kilowatts of solar canopies and rooftop solar panels are installed at the recently constructed Research and Materials Lab in Hopkinton.

The majority of the ROW sites that MassDOT selected are located along the Massachusetts Turnpike (I–90). One site is located on Route 3 in Plymouth.

MassDOT's solar projects were public-private partnerships and required no upfront funding from the State. MassDOT leased the sites to the developer for 20 years, and agreed to purchase all the energy generated through power purchase agreements. MassDOT also benefits from a net metering policy in which the agency receives credits on identified utility accounts. The developer benefits from the guaranteed sale of electricity to MassDOT and through State renewable energy credits and Federal tax incentives.

As of August 2018, the eight sites produced 10,750 megawatt-hours of electricity combined. That amount has resulted in net savings to MassDOT of more than $1 million. MassDOT expects to save approximately $525,000 annually, in addition to the $75,000 received in annual lease payments for the sites.

Moving forward, MassDOT plans to determine which potential solar photovoltaic sites it wants to advance under a new State renewable energy incentive program. The new program favors solar canopies. MassDOT plans to explore installing canopies at Park & Ride facilities.

Maryland: DOT-wide Solar Program

In February 2018, the Maryland Department of Transportation (MDOT) announced plans to install solar power on up to 35 MDOT sites, including buildings and parking lots. Through a bidding process, MDOT selected six master contractors who will compete to provide solar power at MDOT facilities. MDOT will license land to the developer, who will construct, own, operate, and maintain the renewable energy infrastructure. MDOT will buy power at a fixed rate for 20 to 25 years, and expects electricity cost savings of 30 to 40 percent. In addition, the program is expected to generate 298 construction and 28 operations and maintenance jobs, with more positions added as solar expands to other MDOT sites.

"This innovative project allows MDOT to save money, support jobs, and create a resilient, renewable energy source that will benefit Marylanders for decades to come," says Maryland Transportation Secretary Pete K. Rahn.

MDOT estimates that the 35 sites will generate 46,000 megawatt-hours per year, or approximately 12 percent of MDOT's annual electricity usage. The electricity will be used at MDOT facilities or by neighboring residents or businesses, which can subscribe as part of Maryland's Community Solar Pilot Program.

MDOT is also planning for a second phase of the program, which will begin after project implementation at the initial 35 sites. The second phase may involve implementing solar projects at locations such as Baltimore/Washington International Thurgood Marshall Airport, ports, transit-oriented developments, and also on noise barriers and unimproved land.

Renewable Energy Partnerships

Several States with ROW solar installations have used power purchase agreements (PPAs) to finance their projects. PPAs are allowed in at least 26 States and provide one option for State DOTs to implement renewable energy projects with no upfront costs.

Under a solar PPA:

- A contractor finances, installs, operates, and maintains the solar arrays.
- A private-sector partner (either the contractor or another entity) takes tax incentives and sells the electricity produced by the panels to the State DOT.
- The State DOT agrees to a long-term contract to purchase the electricity from the solar panels, typically at a lower rate than it had been paying.

MassDOT installed these solar panels along Route 3 in Plymouth and worked with FHWA to obtain the necessary approvals. *Photo: MassDOT.*

Utah: Exploring ROW Solar

The Utah Department of Transportation (UDOT) has installed several small-scale renewable energy projects at its facilities over the last 10 years. They include a small wind turbine and solar panels on maintenance facilities, UDOT buildings, and parking lot canopies. A total of 321 kilowatts of photovoltaic modules are installed, and they generate approximately 632 megawatt hours annually. These projects help UDOT reduce its electricity bills with the renewable energy produced.

To fund these installations, UDOT relied on matching grants from utilities, the U.S. Department of Energy, and American Recovery and Reinvestment Act programs. However, as a public entity unable to take advantage of tax incentives, UDOT found it difficult to get funding for larger projects.

In 2017, UDOT began to consider ROW solar installations. In December 2017, the department issued a request for information about the feasibility of pursuing solar projects in UDOT ROW. UDOT received six responses, all of which found that UDOT could break even or save money by putting solar power in the ROW. UDOT has identified several potential sites for ROW solar projects and is moving forward with developing a request for proposals for a PPA.

Supporting State Efforts

FHWA offers several resources intended to help State DOTs develop renewable energy projects. Resources are available at www.fhwa.dot.gov/real_estate/right-of-way/corridor_management/alternative_uses.cfm. Some examples include:

- A briefing book, *Renewable Energy Generation in the Highway Right-of-Way* (FHWA-HEP-16-052), which provides an overview of highway renewable energy project business models, funding sources, and regulatory requirements, as well as case studies and sample pilot projects.
- A *Quick Guide* that points transportation agencies to the relevant Federal regulations on ROW renewable energy projects.
- Reports documenting four peer exchanges at which State DOTs and other practitioners shared information on accommodating renewable energy technologies in the ROW.
- Research reports on topics related to alternative uses of the ROW, including photovoltaic noise barriers and sustainable rest area design and operations.

As interest in ROW renewable energy continues to grow and the technologies available expand and drop in price, FHWA plans to continue to support transportation agencies in their renewable energy efforts.

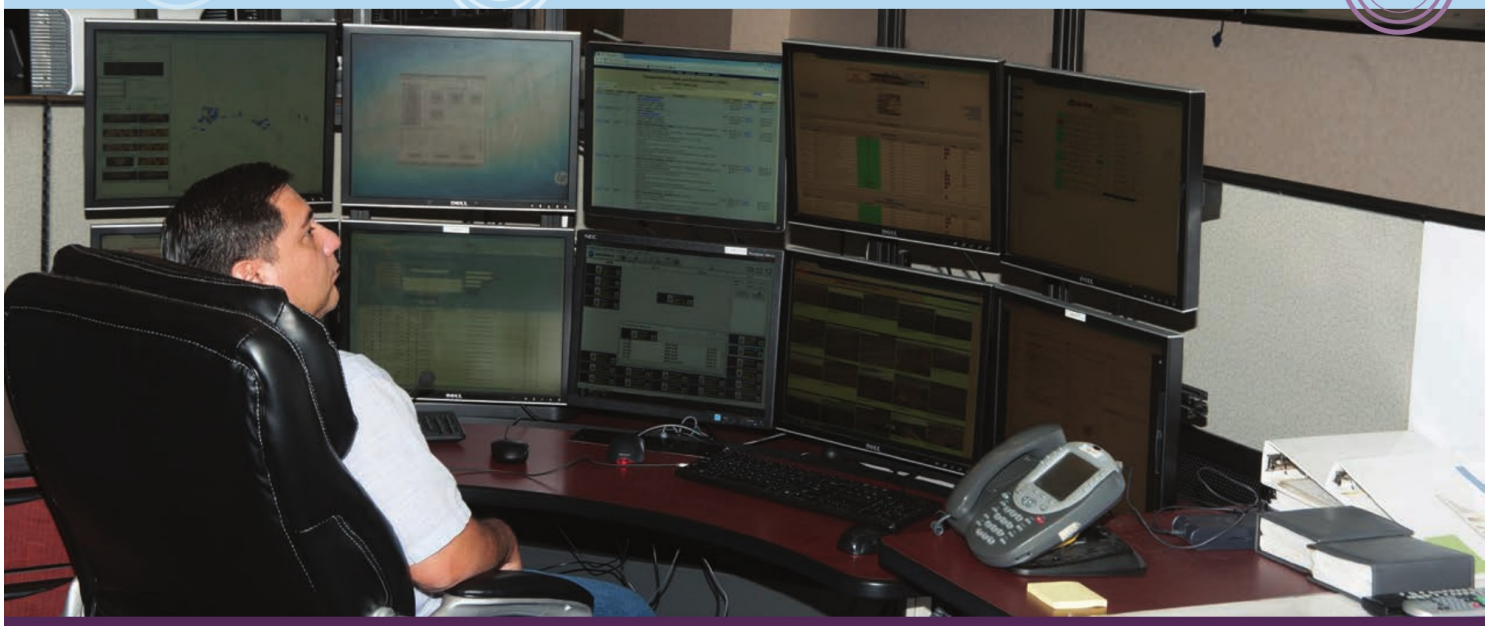
UDOT is implementing solar canopies in a parking lot at its headquarters in Salt Lake City. This aerial view shows the first phase completed and the second phase underway (to the far right). *Photo: UDOT.*

Tina Hodges is an environmental protection specialist at FHWA. She conducts research, technical assistance, and outreach to improve the sustainability of transportation networks and enhance the resilience of transportation to climate change impacts. She has 13 years of experience on these issues at FHWA and the Federal Transit Administration. She holds a master's degree in public policy from the University of Maryland.

Amy Plovnick is a community planner at the U.S. Department of Transportation Volpe Center. Her work involves research, coordination, and policy analysis for projects related to resilience, sustainability, active transportation, and transportation planning. She has a master's degree in city planning from the Massachusetts Institute of Technology and a B.A. in political science and environmental studies from Washington University in St. Louis.

For more information, see www.fhwa.dot.gov/real_estate/right-of-way/corridor_management/alternative_uses.cfm or contact Tina Hodges at 202-366-4287 or Tina.Hodges@dot.gov.

FOCUS ON—CONNECTED VEHICLES



Getting Connected in Wyoming

The Wyoming Department of Transportation is integrating data from connected vehicles into its statewide transportation management center. Here's a closer look at the process.

by Edward Fok, Vince Garcia, and Kate Hartman

(Above) In Wyoming, transportation management centers (TMCs) play a major role in integrating connected vehicle data into a highway agency's systems. Here, an operator in the Wyoming Department of Transportation TMC is monitoring highways by watching a plethora of screens displaying road and weather condition information. *Photo: WYDOT.*

The ability to share and use electronic messages generated and sent by connected vehicle (CV) applications has the potential for immediate beneficial impacts. CVs is a broad term to describe the applications (software) that translate electronic messages shared between connected devices (hardware and traffic management systems) into the formats required to enable the use of this information. These applications and devices are designed to save lives, improve personal mobility, enhance economic productivity, reduce environmental impacts, and transform public agency operations.

On September 1, 2016, the U.S. Department of Transportation awarded three cooperative agreements—collectively worth more than $45 million—to initiate a design-build-test phase of the Connected Vehicle Pilot Deployment Program in New York City; Tampa, FL; and Wyoming. The program is a national effort to deploy, test, and operationalize cutting-edge mobile and roadside technologies and enable multiple CV applications.

For its CV pilot, the Wyoming Department of Transportation (WYDOT) plans to equip 400 vehicles with onboard units and deploy around 75 roadside units (RSU) along the State's 402 miles (647 kilometers) of I-80.

From October 2015 to September 2016, there were more than 1,600

crashes on I–80 in Wyoming, including 18 with fatalities and 271 with injuries. During that same time period, roads were closed to all vehicles for more than 1,500 hours. The societal impact of these crashes topped $865 million.

In Wyoming, participation in this program came with the realization that the pilot would require the integration of the electronic messages generated by CVs into WYDOT's existing traffic management system and its day-to-day operations.

"Wyoming considers CVs the perfect tool to overcome the area coverage limitations of its fixed data collection stations on its highway network," says Bill Panos, WYDOT director. "From the concept development stage, we considered how the new technologies and data fit with existing functions of the agency and the statewide transportation management system."

The Transportation "Hub"

WYDOT's Transportation Management Center (TMC) serves as the nerve center of managing the day-to-day operation of Wyoming's highways. The TMC is responsible for maintenance dispatching on roadways and serves as the hub for all road condition, incident, and construction reporting activities that affect the transportation system.

The TMC is staffed 24/7 with up to seven people on the floor during winter storms and as few as two on calmer summer days. The TMC receives information from State Patrol dispatch, WYDOT maintenance employees, trained volunteers, and WYDOT construction employees via radio, phone, and electronic submission. Staff use the information to update reporting systems. The TMC staff also work closely with an onsite meteorologist and the National Weather Service to anticipate weather-related issues, plan for appropriate road maintenance, and send a consistent message to the public about what to expect.

For the pilot deployment, integrating and using data from CVs into the TMC was critical. The TMC is the host of traffic operations-related data, data management, and communication tools (used to send information to third parties). Functionally, the TMC is the entity in charge of ingesting, processing, archiving, and distributing information related to the day-to-day operation of the roadways managed by WYDOT, making it a natural fit for adding and managing data captured from CVs.

Traveler Information

WYDOT houses and supports many tools that disseminate traveler and roadway condition information to thousands of users of Wyoming's highway network. Two important examples are WYDOT's 511 system and the Commercial Vehicle Operator Portal. More than 870,000 phone calls come into the 511 phone system during an average winter each year, and the 511App has more than 130,000 downloads. Likewise, more than 150 companies have signed up to be part of the Commercial Vehicle Operator Portal, which currently provides forecasted road condition information on common commercial vehicle routes for freight operations via its website.

These are two examples of the tools that will provide information to or receive information from Wyoming's CV pilot project.

Challenges with Sharing Information

CVs present a challenge for traffic management systems because of the granularity, speed, and volume of data they collect, save, and use. WYDOT was mainly concerned with maintaining a sustainable workload for the staff involved in the operation of the TMC, ensuring that the TMC would be able to continue operation in the event of a CV system failure and guaranteeing a secure system that respects the privacy of users.

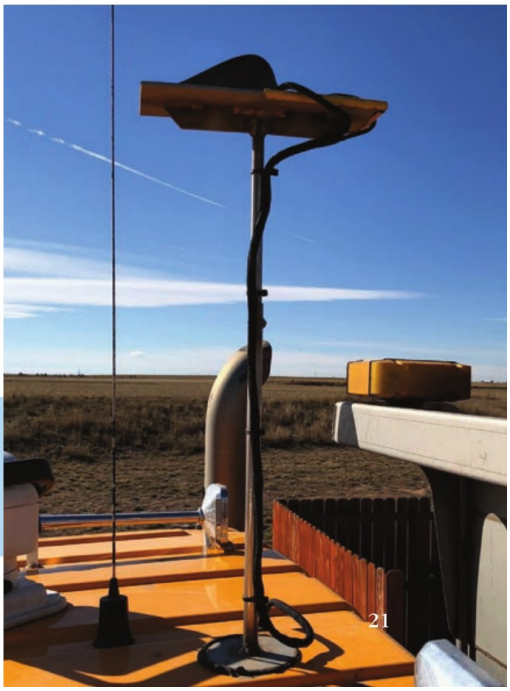
"Budgets are tight, and we can't expect to get additional personnel in our TMC to carry out any additional functions or services that may be required to use data generated from CVs," says Kevin Cox, TMC supervisor with WYDOT. "As such, it's critical that we integrate the use of CV data into the existing functions and operation of our TMC."

WYDOT staff already have a significant burden on their shoulders, ensuring that all highway maintenance and operation work is performed as fast and efficiently as possible. WYDOT wanted to ensure that its staff would not be further burdened with "making the system work," but rather that the new pilot project would be perceived by the staff as another source of information—another "tool in their toolbox"—that seamlessly integrates with their daily operation.

Critical to the challenge was finding a way to translate electronic messages sent by CVs into actionable information. Data produced by CVs could not be directly transmitted to the TMC operators in an unprocessed or unfiltered state because the information would not be useful to them. For WYDOT, it was imperative to integrate CV data into the TMC without having to completely rebuild the TMC.

Finally, WYDOT was concerned about security risks to the TMC that may arise from collecting and sharing data generated by CVs. Arguably, the main challenges with any system sending and receiving data are ensuring it is done securely and protecting sensitive data. It was important for WYDOT to consider potential security breaches of the system, as well as possible compromises of sensitive information, as the agency sought the continued participation of the freight industry during and after the pilot project.

Maintaining a secure and private system provides a challenge to agencies from an operations and



This dedicated short-range communications antenna, installed on a WYDOT snowplow, enables communication between vehicles and infrastructure. *Photo: WYDOT.*

This human-machine interface (a tablet computer) is installed in a WYDOT snowplow. *Photo: WYDOT.*

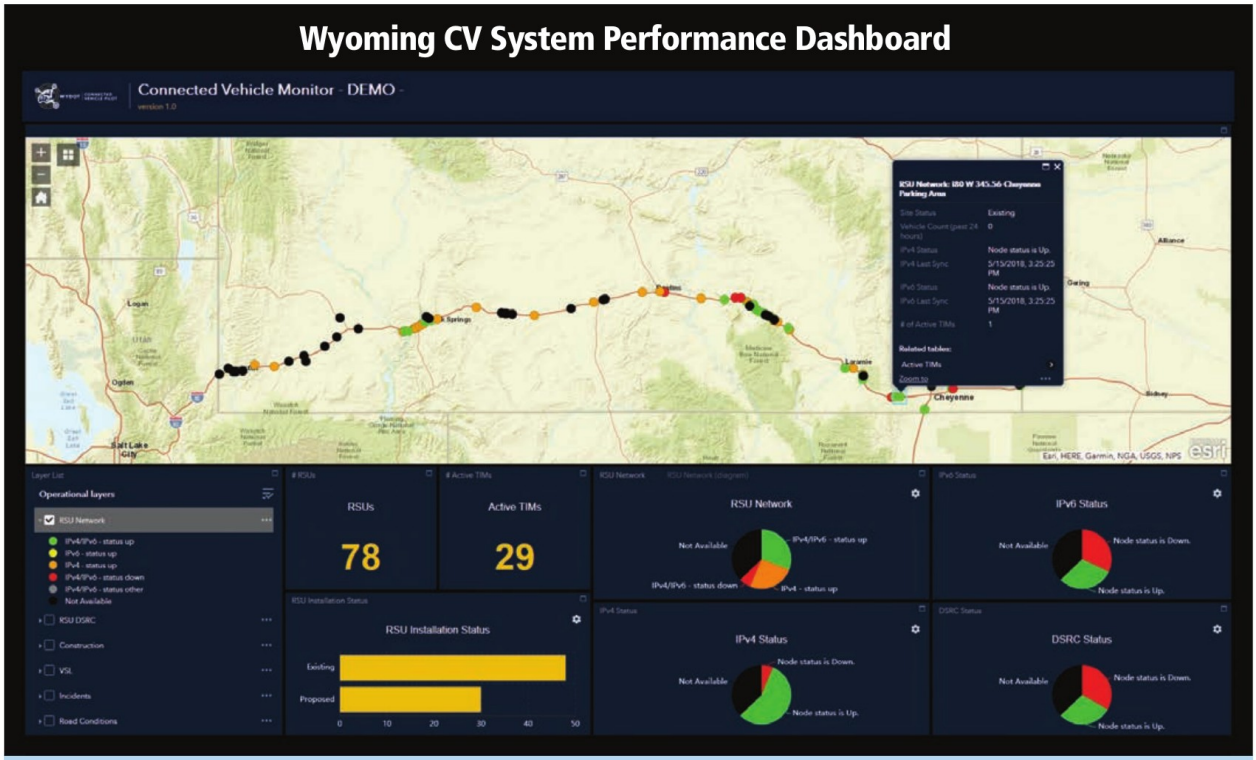
monitoring perspective. The question is, how can you monitor and measure the full impact of a system while maintaining the required levels of privacy? The focus is on ensuring data from messages sent by CVs are collected, used, and shared in a manner that ensures the protection of sensitive information. WYDOT needs to prove to Wyoming's policy/decisionmakers and to its constituents that this technology worth investing in beyond the duration of the pilot project.

Lessons Learned

WYDOT used a system engineering approach to develop the design, deployment, and operation guidelines of its pilot project. During the design process, WYDOT assessed what existing external assets and internal capabilities of the TMC it could leverage, resulting in interfaces and modifications made to the TMC to support the project. In general, the project consists of devices installed on vehicles, devices installed within the roadway of the area being tested, and modifications to WYDOT's TMC.

WYDOT's experience in developing and integrating data from CVs into its TMC while considering the security, data management, and operator requirements highlighted the following practices and lessons learned.

Leverage existing open-source software to integrate CV data into the TMC. WYDOT identified



The performance dashboard illustrates the connection and performance status of all roadside infrastructure. *Source: WYDOT.*

A member of the WYDOT crew installs the onboard units.
Photo: WYDOT.

current efforts to develop software and work in conjunction with the developers to integrate them into the CV pilot project. This helped save significant time and yielded a more robust system, one built on top of previous experience.

Examples of software components that were incorporated into this project are the Intelligent Transportation Systems (ITS) Joint Program Office's (JPO) Operational Data Environment (ODE) and the National Center for Atmospheric Research's Pikalert®. The ODE ingests and processes connected vehicle data from various devices—including vehicles, infrastructure, and TMCs—and distributes the information to selected components of a traffic management system (for example, data warehouses). Pikalert ingests weather data from different sources, including CVs, and generates advisories on current and forecasted road and weather conditions for a variety of users.

Focus on the interfaces. WYDOT's design approach highlighted the advantages of focusing on which interfaces the team needed to develop to send, receive, and manage electronic messages or specific CV data. This strategy helped identify the gaps in existing systems and the devices and changes needed to the TMC software and hardware platforms to enable the exchange and use of new data. WYDOT was able to sort out which ITS applications could remain as-is, which needed to be developed and deployed, and which needed modifications.

Have a "friendly" vehicle fleet (if possible). WYDOT employed security and safety procedures to eliminate the tracking of all equipment or devices used for the pilot project (for example, equipment installed on participating commercial vehicles that are privately owned). However, WYDOT was able to equip many of its own vehicles it could track and control, such as its own snowplows, enabling a more robust monitoring of the system's operational performance, especially during the testing phase.

Translate CV data into information for the TMC. WYDOT estimates the CV pilot project produces about 50 million electronic messages per day in addition to the 1 million already being generated by variable speed limit sensors and road weather information systems. TMC operators simply cannot interpret these electronic messages in their entirety given their magnitude and format. Building from past experience, WYDOT clearly needed tools and procedures to ingest, process, and analyze CV data—more than those that exist in a research and development environment—to provide actionable data to TMC staff. The WYDOT TMC uses both the ODE and Pikalert systems to translate raw CV data, such as basic safety messages, into discrete, useful information for TMC operators.

Create user-friendly dashboards and tools to monitor performance. A clear need exists for dashboards to enable continuous monitoring of the various hardware and software that compose the CV pilot project. The dashboards serve multiple purposes for WYDOT—from providing visibility of the entire CV pilot infrastructure deployment for TMC operators to providing important data for performance measurement and becoming an effective public engagement tool (the public can see the posted messages and how many CVs have passed by the roadside units).

Create a security and data management framework. From the beginning, WYDOT envisioned a project that would follow "secure by design" principles that cover the process of forming, distributing, collecting, using, storing, and discarding data from CVs and TMC systems. To do this, the team looked at the human and technical aspects of the TMC to ensure they employed proper data management techniques. Every member of WYDOT's project team and TMC who might have access to the data was required to pass a background check and successfully complete hours of training on ethical research and protection of personally identifiable information. Access to information is limited to those individuals who need it for their job functions.

WYDOT has employed advanced encryption of databases and in-transit data packets, along with employing firewalls, hardware security modules, and software developed by USDOT to credential authorized vehicles that participated in this project. The entire project, from vehicle to the TMC, was evaluated to ensure the latest security techniques were in place.

Involve broader State enterprise. Integrating CV data into existing systems and operations requires a team effort with different skills to plan, design, develop, modify, and test the changes needed in both hardware and software. WYDOT reached out to several departments and divisions within its institutional structure, including Telecommunications, Enterprise Technology Services (the State's centralized information

WYDOT crew members also installed roadside units, as shown here. *Photo: WYDOT.*

technology agency), the Equipment team, and the Maintenance team, and involved them in the project early on.

Re-envision existing systems. WYDOT not only leveraged efforts by other agencies/institutions, but also looked internally at its own systems and capabilities. WYDOT already had a robust network of data users and data suppliers—with its many traveler information outlets being visited and used by thousands of I–80 users on a daily basis—an efficient data distribution system, and a secure data archiving system. WYDOT assessed each component and identified how it could improve each one to further extend the reach of the CV pilot project. For instance, WYDOT extended its Commercial Vehicle Operator Portal and modified the Transportation Report and Action Console to accommodate Pikalert's advisories and alerts. Similarly, WYDOT upgraded its incident and construction consoles to automate processes, improving its integration and management of CV data.

Develop a critical path for development. Wyoming's project deployed five applications on devices installed in vehicles along with updates to several components to WYDOT's traffic management and traveler information systems. Given the varying degree of interdependencies, WYDOT used an agile development approach instead of the traditional waterfall approach (that is, in sequence) to develop this project. This enabled WYDOT to reach its goals within the tight schedule for development.

Moving Forward

In Wyoming, the integration of data from CVs into the TMC is not only providing more robust information for road management, but it is also propelling the revamp of existing services. The planning, design, and deployment of the CV pilot project has already positively impacted WYDOT's TMC, helping the agency identify gaps in its existing systems and policies, as well as identifying "low-hanging fruits" for improvement.

Technologies are already installed on some vehicles to provide CV-related functions, and many of these functions are expected to be common among all vehicles in the future. With this in mind and by understanding the positive impact these technologies may have on the surface transportation system, WYDOT intends to continue to offer a functioning system to support the use of connected devices installed on vehicles after the performance and evaluation period of the pilot project, which ends in April 2020. The installed roadside units and all invehicle equipment will remain operational in WYDOT vehicles. WYDOT is encouraging fleet partners to continue being part of the system.

WYDOT sees the integration of CVs into its TMC as instrumental for improving road management capabilities on I–80 and the rest of Wyoming's highways. "Assuming the pilot proves successful, we hope to expand the project statewide and to introduce new vehicle-to-everything applications as they become available," says Pat Lewis, chief technology officer at WYDOT. "WYDOT is also looking into adjacent States to coordinate any efforts to further expand and connect corridors."

Look for more features on connected vehicles in upcoming issues of PUBLIC ROADS.

Edward Fok is a transportation technologies specialist with FHWA's Resource Center. Fok is experienced in many facets of advanced transportation systems for both metropolitan and Federal governments. One of his current roles is FHWA's lead on tackling transportation cyber resiliency challenges. He holds an M.S. in electrical engineering and a B.S. in mechanical engineering. He is a licensed electrical engineer and transportation engineer.

Vince Garcia has worked for WYDOT in various capacities for more than 30 years. Currently, he manages the GIS/ITS Program for WYDOT and serves as the site lead for the CV pilot project. He is a graduate of the University of Wyoming with a degree in civil engineering.

Kate Hartman has more than 15 years of experience at the USDOT and serves as chief of research, evaluation, and management at the ITS JPO. She has worked in CV technology research for a number of years and currently manages the USDOT CV Pilot Deployment Program. She has a B.A. in economics, an M.B.A., and a Project Management Professional® certification.

For more information, including frequent updates, resources, and documentation on the USDOT CV Pilot Deployment Program, see www.its.dot.gov/pilots/index.htm. For updates on the Wyoming CV pilot project implementation, see https://wydotcvp.wyoroad.info or contact Vince Garcia at 307-777-4231 or Vince.Garcia@wyo.gov.

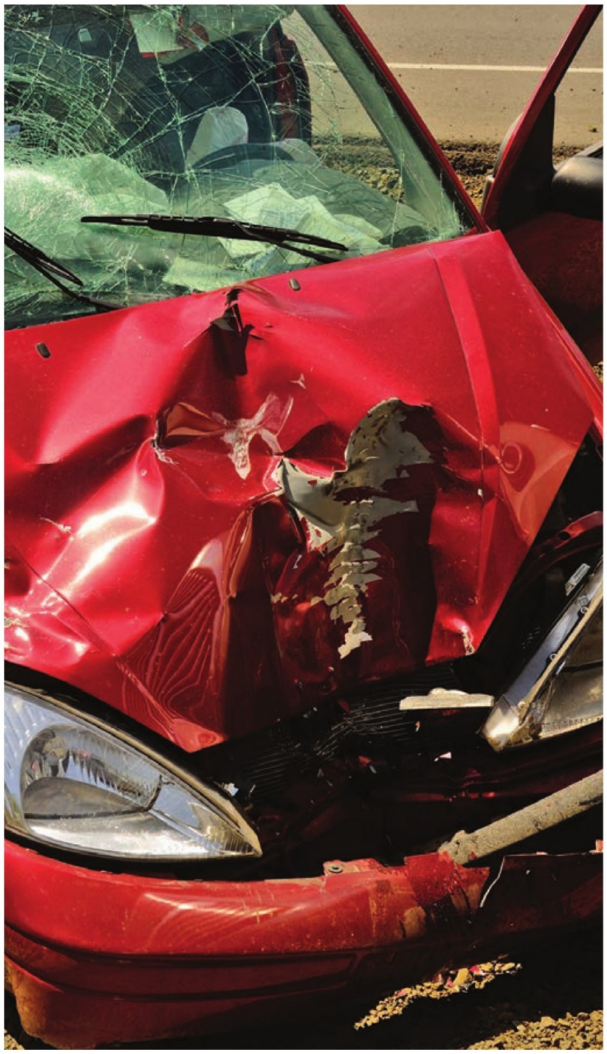
Along the Road

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

Public Information and Information Exchange

Data Show Roadway Fatalities Decreasing

The National Highway Traffic Safety Administration recently released 2017 statistics that show highway fatalities are down following 2 consecutive years of significant increases. In addition, preliminary estimates for the first 6 months of 2018 appear to show that this downward trend continues into this year.



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Roadway fatalities fell nearly 2 percent in 2017.

In 2017, 37,133 people died in motor vehicle crashes, a decrease of 1.8 percent from 2016. In addition, pedestrian fatalities declined about 2 percent, the first decline since 2013, and the fatality rate per 100 million vehicle miles traveled decreased by 2.5 percent—from 1.19 in 2016 to 1.16 in 2017—despite a 1.2-percent increase in vehicle miles traveled. However, the number of combination trucks involved in fatal crashes increased 5.8 percent. For the second year in a row, more fatalities occurred in urban areas than rural areas.

The 1.8-percent decrease from 2016 to 2017 contrasts the 6.5-percent increase from 2015 to 2016 and the 8.4-percent increase from 2014 and 2015.

For more information, visit https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812603 and https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812629.

NHTSA

USDOT Tests Connected Vehicles

The Federal Highway Administration's Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA, successfully hosted a connected vehicle pilot program in partnership with USDOT's Intelligent Transportation Systems (ITS) Joint Program Office (JPO) in June 2018. The event, which was the largest and most successful interoperability testing of connected vehicle equipment to date, involved more than 100 test runs, 75 supporting participants, and 7 different vendors who provided equipment.

The goal of the program was to observe and analyze how well connected vehicle devices from various manufacturers operated and interacted with each other. Another goal was to analyze site configuration and the infrastructure needed to support connected vehicles.

Researchers are analyzing the data from the completed testing. Based on the results, manufacturers and programmers will take steps to improve the devices and software configuration, if necessary.

The testing has already shown great promise. One participant noted that this was the first time in history

USDOT ITS JPO

Drivers of connected vehicles proceed onto TFHRC's closed testing course with connected roads and infrastructure during a pilot program in June 2018.

USDOT ITS JPO

Tony English of the Wyoming Department of Transportation participates in the connected vehicle pilot test.

that multiple devices were shown working with the security credential management system, a message security solution for vehicle-to-vehicle and vehicle-to-infrastructure communication.

For more information, contact Deborah Curtis at 202-493-3267 or deborah.curtis@dot.gov.

USDOT to Fund New UTCs

USDOT recently completed accepting applications for two new university transportation centers (UTCs). One center will focus on congestion relief while the other will focus on improving the durability and extending the life of transportation infrastructure.

Funding for the new UTCs was appropriated in the Consolidated Appropriations Act of 2018. Applications closed in December 2018, and USDOT anticipates announcing the awards of $7.5 million for each center in spring 2019.

Each UTC is a consortium of 2- and 4-year colleges and universities that come together to form a unique center of transportation excellence on a specific research topic. The UTCs conduct research that directly supports the priorities of USDOT to promote the safe, efficient, and environmentally sound movement of goods and people. The centers work with regional, State, local, and Tribal transportation agencies to help find solutions to challenges that directly impact their communities and affect the efficiency of the Nation's transportation system. The centers also enable students to work on cutting-edge transportation research.

For more information, visit www.transportation.gov/utc or contact Nancy Wilochka at 202-366-5128.

DelDOT Adds Suicide Prevention Signs to Bridges

The Delaware Department of Transportation (DelDOT) recently installed suicide prevention signs on five New Castle County bridges: Tyler McConnell Bridge, Rising Sun Bridge, Augustine Cutoff Bridge, the I-95 bridge over Brandywine River, and the I-495 bridge over Christina River.

DelDOT

DelDOT installed suicide prevention signs like this one on five bridges in New Castle County.

In 2017, 114 lives were lost to suicide in Delaware. The signs include the message "When it seems like there is no hope, there is help." They also include the number of the National Suicide Prevention Lifeline—1-800-273-TALK (8255)—and the words "Suicide Prevention" in English and Spanish.

"Someone who is considering taking their own life may feel like there is no one out there for them. By placing these signs along these bridges throughout New Castle County, we're sending a message to people: There is someone there. There is someone who will listen and who can help. If we can deter one person from taking their life, then these signs have more than served their purpose," says State Representative Valerie Longhurst, who made the request to DelDOT for the signage.

DelDOT

Australia and Michigan Sign Cooperative MOU

In October 2018, the Australian Government and the State of Michigan signed a memorandum of understanding (MOU) to collaborate on high-tech vehicle and road systems. The MOU was signed by Kirk Steudle, director

University of Melbourne

Kirk Steudle, director of the Michigan Department of Transportation (seated, left), and Andrew Broad, assistant minister to Australia's Deputy Prime Minister (seated, right), signed an MOU between Michigan and Australia to collaborate on intelligent transportation research. Also pictured are representatives from Australia and Michigan who attended the signing.

of the Michigan Department of Transportation, and the Honorable Andrew Broad, Australia's assistant minister to the Deputy Prime Minister.

The signing took place at the University of Melbourne, which has played a central role in advancing the transport technology agreement between the governments of Australia and Michigan. ITS Australia and Austroads, along with the University of Melbourne, are included in the MOU as keys to supporting the bilateral cooperation on connected, automated, and autonomous vehicle technologies occurring across the Australian and Michigan ITS communities. Austroads is a lead organization of Australasian road transport and traffic agencies. ITS Australia is an independent, nonprofit membership organization representing ITS suppliers, government authorities, academia, and transport businesses and users.

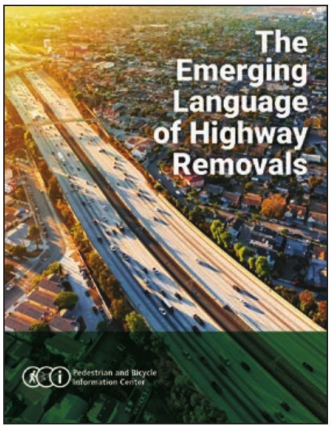
Activities in Michigan and Australia are leading the development of intelligent transportation technology. The MOU supports links between the Australian Integrated Multimodal EcoSystem (AIMES), home to a live test bed on Melbourne city streets, and Michigan's Mcity and American Center for Mobility offroad facilities that will be highly beneficial in progressing advancement in this field.

ITS Australia

Defining the Language of Highway Removals

The Nation's highway system provides connections to population centers, support for interstate commerce, and critical infrastructure for interstate freight movement. But in some urban communities, highways have had unintended consequences, such as dividing neighborhoods, creating barriers to walking and bicycling, and occupying valuable developable land in the hearts of inner cities. In some cases, this has led highway planners to rethink, remove, or relocate urban highways.

There are benefits and drawbacks to removing or changing a highway that runs through a city. A shared language and understanding can help communities explore the best options for their context. To help, the Pedestrian and Bicycle Information Center (PBIC) recently published *The Emerging Language of Highway Removals*. The publication provides language and vocabulary for communities to have informed conversations about removal and mitigation projects and an understanding of available tools. For every definition and concept, the report includes useful graphics to help practitioners visually explain the options.



PBIC

For more information, the publication is available at www.pedbikeinfo.org/pdf/PBIC_HighwayRemoval_060618.pdf.

PBIC

Internet Watch

by Stuart Thompson and Frank Goss

Finding the Right Safety Tool for the Job

Sometimes finding the right data solution is like looking for a hammer and only finding a screwdriver. While a multitude of new safety data and analysis tools support data-driven decisionmaking, the identification and selection of an appropriate tool can be a daunting task. To help, the Federal Highway Administration developed the Roadway Safety Data and Analysis Toolbox.

"There is a wealth of resources in the area of road safety, and new guides and tools are released regularly. It can be difficult to figure out where to start when you are looking for safety-related tools," says Ida Van Schalkwyk, a safety, policy, and innovations engineer at the Washington State Department of Transportation. "The toolbox can help to identify potential resources and find the latest version of guides and tools."

The toolbox is available at https://safety.fhwa.dot.gov/rsdp. It includes guides, software, and databases from diverse sources. A Web-based interface helps users filter and search through more than 200 safety data and analysis tools based on self-identified needs, capabilities, and resources.

The virtual toolbox serves as a clearinghouse of roadway safety data and analysis tools to meet a wide range of user needs. The tools are divided into four categories: Manage, Analyze, Collect, and Research. The Manage tools can help managers develop policies and practices, set budgets, allocate resources, make safety investments, identify training needs, and manage a safety program. The Analyze section offers information about the use, strengths, limitations, and data requirements of analysis tools and methods to help agencies get the most out of the dollars they spend. The Collect tools can help data collectors and stewards understand what safety data to collect, how to collect and maintain data, how to ensure quality, and how to integrate various sources of data for analysis. Research supports continuous improvement of data and analysis techniques as the science of safety continues to evolve. This section provides information about various datasets and new analysis techniques that can help facilitate safety research.

New Additions

Since the launch of the toolbox in April 2015, FHWA has removed and replaced obsolete tools, updated links, and added new tools. Most recently, FHWA added the following five information guides.

The *All Roads Network of Linear Referenced Data (ARNOLD) Reference Manual* helps users to understand the importance and value of high quality safety data. It offers information on how to establish or evaluate safety management policies and practices, develop integrated safety data systems, and assess resources required to collect and manage safety data.

Road Safety Fundamentals provides information on the importance and value of data-driven decisionmaking, how to establish or evaluate safety management policies and practices, and how to enhance collection and management techniques for safety data.

The Model Inventory of Roadway Elements (MIRE) *2.0* provides a structure for roadway inventory data that enables State and local transportation agencies to use analysis tools with their own data rather than rely on default values that may not reflect local conditions.

Crash Costs for Highway Safety Analysis (FHWA-SA-17-071) describes the various sources of crash costs, current practices used by States, and critical considerations when modifying and applying crash unit costs. It also explores the feasibility of establishing national values for crash unit costs.

The Highway Performance Monitoring System (HPMS) Field Manual provides a comprehensive overview of the HPMS program and describes the data collection and reporting requirements for HPMS.

Maintaining an Up-to-Date Resource

FHWA's Roadway Safety Data Program welcomes input from users to improve and update the toolbox through three methods. There are links from the home page to provide general feedback, submit information on a particular tool or resource to be added to the toolbox, or identify gaps without suggesting a specific tool. Future updates will add case studies, enhanced search functions, links to additional resources, brief training videos, and topic-based overviews.

For more information, contact Stuart Thompson at stuart.thompson@dot.gov.

Stuart Thompson is a transportation specialist with FHWA's Office of Safety Roadway Safety Data Program.

Frank Goss is a highway safety engineer with Vanasse Hangen Brustlin (VHB).

Source: FHWA.

Training Update

NATIONAL HIGHWAY INSTITUTE

by Mary Burke

Collecting and Interpreting Safety Data

When it comes to the road, there is no such thing as absolute safety. That is why safety stakeholders like transportation agencies and law enforcement professionals integrate safety into every step of decisionmaking processes. Safety data, such as crash frequency and severity, are crucial to creating more secure roads. The ability to collect and analyze this information can support critical decisionmaking efforts across an organization.

To help with this task, the Federal Highway Administration's Office of Safety developed a free, Web-based course available through the National Highway Institute. The course offers detailed safety data and analysis training with four different tracks tailored to individual goals. Safety Data and Analysis Fundamentals (course 380122A-D) equips transportation professionals from every level with the knowledge they need to effectively collect and interpret safety data.

In this innovative online training, participants learn key safety data types and terms and walk away with strategies for identifying data weaknesses and strengthening the way they use safety data in their programs, projects, and communities.

"Data-driven safety analysis has been shown to quantitatively measure and even predict reductions in fatal and serious injury crashes," says course developer Esther Strawder with the FHWA Office of Safety. "As such, FHWA recently put safety data system requirements in place for States to develop performance-based targets and measures. This course will help States better understand why and how data-driven safety analysis leads to safer roadways for everyone."

Four-Track Curriculum

To target the content to specific audiences, course developers designed four tracks based on the participant's professional goals, responsibilities, and roles:

Data analysts. This track emphasizes the applicability, uses, strengths, limitations, and requirements of safety data and collection methods. It is intended for anyone responsible for analyzing safety data to identify causes and potential patterns that contribute to crashes and other systemic safety issues, including highway safety engineers, specialists, traffic engineers, highway designers, and technical analysts.

Data collectors. This track emphasizes the ways data collectors support the needs of data analysts and helps managers use data to make strategic, informed decisions about safety priorities. It is recommended for anyone who collects crash, traffic, roadway, behavioral, injury, or other safety data, including law enforcement officers, emergency medical service providers, trauma registrars, driver and vehicle service clerks, and roadway data collectors.

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Transportation professionals rely on safety data to identify weaknesses in current practices and improve transportation programs and projects.

Project/program managers. This track emphasizes the tradeoffs of project alternatives in terms of costs and benefits, including safety impacts of the project/program, as well as the individual components. It is targeted toward professionals responsible for using safety analytics to identify and prioritize safety issues, develop and implement countermeasures, and evaluate project/program effectiveness. The track is recommended for transportation planners, traffic records coordinating committee members, highway safety online directors, and State and local mid-level managers (such as division and district program managers in highway safety, design, traffic, engineering, enforcement, and public health).

Senior managers/safety advocates. This track emphasizes understanding the needs of data collectors, data managers, and data analysts in terms of equipment, human resources, and organizational structure. It helps bridge the gap between the public, practitioners, and those who are responsible for developing or influencing policies and practices, setting budgets, allocating resources, and making safety investments. It is recommended for State and local senior managers, such as division heads/chiefs of transportation, planning, civil engineering, and public health professionals.

"We developed an interactive curriculum that serves targeted content based on participant goals and the role they play in transportation safety," says Strawder. "This targeted method means professionals get the most from the training."

For more information, contact Esther Strawder at esther.strawder@dot.gov. To register for the course, visit www.nhi.fhwa.dot.gov and search for course number 380122.

Mary Burke is the marketing manager at the National Highway Institute.

Communication Product Updates

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

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

When ordering from NTIS, include the NTIS publication number (PB number) and the publication title. You also may visit the NTIS 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:

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

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

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

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

Smart Vehicles, Smart Signals, Smart Cities (Fact Sheet)
Publication Number: FHWA-HRT-18-032

As the Nation's urban population increases, so does the number of vehicles on city streets. The resulting congestion contributes to increased or unreliable travel times. For its 2016 Urban Congestion Trends report, FHWA calculated the average daily duration of congestion in 52 of the largest U.S. metropolitan areas at 4 hours and 43 minutes, up from 4 hours and 22 minutes 5 years earlier. However, the emergence of automated vehicles could help improve urban mobility if the vehicles can safely integrate into cyber-physical systems that also include technologically advanced traffic signals and road sensors.

In partnership with the National Science Foundation, FHWA's Exploratory Advanced Research Program is supporting three research projects with applications of cyber-physical systems for highway transportation officials to understand how to scale public benefits of new technologies. All three projects demonstrate the potential of cyber-physical systems in transportation, which can improve mobility and economic strength throughout the Nation.

This fact sheet provides an overview of each of the three research projects. The document is available to download at www.fhwa.dot.gov/publications/research/ear/18032/index.cfm.

Properties and Behavior of UHPC-Class Materials (Report)
Publication Number: FHWA-HRT-18-036

The highway industry is adopting ultra-high performance concrete (UHPC) for a variety of bridge construction and rehabilitation applications. In North America, the most popular application of UHPC in bridge construction is for field-cast closure pours between adjacent prefabricated bridge elements, which are employed in many accelerated bridge construction projects. This application has proven to be a common entry point for many bridge owners.

As the demand for this innovative class of materials increases, so will the need for knowledge regarding the material properties and characteristics. To fill this knowledge gap, researchers at FHWA's Turner-Fairbank Highway Research Center executed an experimental study on six different commercially available materials being marketed as "UHPC class."

The goal of the research was to provide the bridge engineering community with a more comprehensive set of properties for this class of materials, which can facilitate broader use within the

sector. Researchers evaluated the UHPC-class materials using 14 different test methods developed by ASTM (formerly the American Society for Testing and Materials), the American Association of State Highway and Transportation Officials, or FHWA.

Results indicate that these materials behave similarly with respect to some performance measures—such as compressive strength, tensile strength, and durability—but vary with respect to other measures, such as dimensional stability, bond to precast concrete, and compressive creep.

The document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/18036/index.cfm.

Driver Acceptance of Connected, Automation-Assisted Cruise Control—Experiment 1 (Report)
Publication Number: FHWA-HRT-18-041

This report documents the results and conclusions of an initial experiment that examined human factors issues in the use of adaptive cruise control (ACC) and a hypothetical cooperative ACC (CACC), which is an ACC system enhanced with vehicle-to-vehicle (V2V) communications to share information on speed, brake position, and distance between vehicles. In this driving simulator-based experiment, researchers modeled the CACC system to accelerate and decelerate less aggressively when the ACC radar lost track of the vehicle on a curve.

The experiment tested three cruise-control displays. One display showed only whether cruise control was turned on or off. A second display showed not only whether the display was on or off, but also whether the system was tracking another vehicle. A third display showed which vehicle was being tracked.

The goals of this project were to improve the general understanding of the human factors issues related to vehicle automation, perform experiments to support research on level 1 vehicle automation, and publish information to support the development of standards and performance requirements for level 1 vehicle automation. Level 1 automation refers to partial automation of either steering or braking and acceleration where the driver is expected to monitor and intervene as needed.

The study concluded that supplementing ACC with V2V communications may increase the use of the technology and enhance the safety benefits provided by it. This research should be of interest to developers of level 1 automated systems and to safety professionals seeking to understand the benefits and opportunities of this technology to improve roadway safety.

The document is available to download at www.fhwa.dot.gov/publications/research/safety/18041/index.cfm.

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Attendees of the 2017 Professional Leadership Development Academy in Washington, DC. Photo: FHWA.

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