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Summer 2019

Better Access to Bridge Data

CVs Improve Safety in Tampa

The Challenges of Moving Goods

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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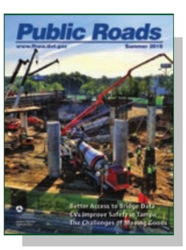

Front Cover—The Georgia Department of Transportation (GDOT) and its partners rose to the challenge to restore mobility on Atlanta's busy Interstate 85 viaduct, a vital north-south corridor, following a fire on March 30, 2017. The fire damaged a portion of the bridge and forced its closure. GDOT partnered with a local contractor to demolish, retrofit, and rebuild the segment in an unprecedented 43 days. For more information, see "Partnering in a Crisis" on page 12 in this issue of PUBLIC ROADS. *Photo: © Georgia Department of Transportation.*

Back cover— Fresh fruits and vegetables, such as these tomatoes, are sold by farmers in various ways, including at grocery stores, at farmers' markets, and even through e-commerce grocers. Transportation by all modes plays a vital role in how food gets from farms and other food producers in the United States and around the world to your dinner plate. For more information, see "From Farm to Table" on page 16 in this issue of PUBLIC ROADS. *Photo: zych © 123RF.*

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Federal Highway Administration

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Guest Editorial

The Power of Partnership

Two years ago, a fire under the Interstate 85 (I-85) viaduct in Atlanta, GA, caused part of the bridge to collapse, severing a freeway that carries 243,000 vehicles daily. Looking back at the aftermath, one common theme emerged that greatly contributed to the successful outcome of rebuilding 700 feet (213 meters) of the bridge in less than 7 weeks: partnership.

Without a doubt, the first essential partnership was from first responders. It is amazing that no one was injured even though the collapse happened during the evening rush hour. The immediate response required coordination between State and local police, fire and rescue teams, and the Georgia Department of Transportation's (GDOT's) Highway Emergency Response Operators (HEROs) to stop traffic and ultimately reroute expressway traffic to keep motorists out of harm's way.

GDOT immediately set up an emergency command center to triage the situation. Partnerships with the Federal Highway Administration, State police and emergency management, the Atlanta Police Department, traffic managers, and transit operators made this possible. The immediate planning focused not only on safety and traffic management, but also on demolition and rebuilding as quickly as possible.

Communications partnerships also played a key role in the success of the rebuild. GDOT's Strategic Communications Office worked collaboratively with members of the media as well as all involved agencies, transit providers, local governments, and the private sector to disseminate critical information, including transit and telework options. Strategic and coordinated messaging was a powerful tool for the team, and not one that GDOT took for granted.

The communications team used multiple social media platforms and provided daily updates to the public including informative video content. In addition, GDOT's Director of Construction, Marc Mastronardi, P.E., invited the media to the worksite twice each week for progress updates. For more information on the rebuild project, see Marc's article "Partnering in a Crisis" on page 12 in this issue of PUBLIC ROADS.

Communication and a strong partnership between GDOT and the

© GDOT

contractor were critical from the very beginning. GDOT's bridge engineers worked around the clock and shared design details, calculations, and quantities with the contractor in real time, as plans developed. This enabled the contractor to order materials and schedule crews much faster than waiting until the redesign plans were complete.

GDOT also benefitted significantly from the strong support it received from the U.S. Department of Transportation and Transportation Secretary Elaine Chao. This critical partnership started with a phone call from the Secretary to then Governor Nathan Deal to pledge the Department's and her full support. Having key team members from USDOT and FHWA on the ground in Atlanta the very next morning, and their continuing support throughout the project, exemplified the relationship between GDOT and its Federal partners.

Strong partnerships were critical to the success of rebuilding in just 43 days—more than 5 weeks ahead of the original projection. GDOT is leveraging this experience to focus on a culture of collaboration and innovation that enhances partnerships.

The moral of this story is that you shouldn't wait for an emergency to build a partnership; prepare by building partnerships today because you never know if you will need them tomorrow.

Russell R. McMurry
Russell R. McMurry, P.E.
Commissioner, Georgia Department of Transportation

HOT TOPIC

by Morgan L. Kessler

Advanced Geospatial Tools

Humans have a long history of observing and measuring the earth to find distances, define borders, and create the built environment. People have used tools to accomplish this since the earliest hand-inked maps and now-forgotten measuring units (for example, cubits). Today, with emerging and advanced technological resources available, engineers can address the same needs with unprecedented speed, detail, and flexibility.

The field that gathers and manipulates planetary measurements and imagery is called geospatial analysis. The field employs an assortment of specialized tools, and highway design and construction professionals make extensive use of data from geospatial tools. Recently, technological advances have emerged that are providing increasingly robust geospatial information, with an outcome of powerful new efficiencies in highway design and construction practices. Highlighted in this article are four technologies that represent these advances.

Unmanned Aerial Systems

Unmanned aerial systems (UAS), also called drones, have quickly become versatile platforms for collecting geospatial data. Available in many sizes and forms—with the quadcopter (four rotor blades) being the most common—they are popular for surveying and mapping because of their relatively low cost, ease of use, and fast deployment capabilities.

Increasingly, UAS are employed for other engineering and construction tasks, such as material quantity estimation and field inspection. As the use of UAS increases, it is important that users of this technology understand and follow the rules governing its use.

LiDAR

A technology gaining traction for geospatial use is light detection and ranging, more commonly known as LiDAR. These laser-based devices can rapidly acquire three-dimensional (3D) geometric data (termed "point clouds") efficiently and with unprecedented detail.

With advancements in sensor miniaturization and reduced power needs, LiDAR units are now adaptable to many platforms, including aerial (UAS), terrestrial (tripod), and mobile (vehicle). Accuracy levels vary by platform type, and users should be aware of these differences and their potential impacts on a project.

Structure from Motion

Using principles that are not fundamentally different from those of conventional photogrammetry (the art and science of taking measurements from photographs), Structure from Motion (SfM) is a technique that uses advanced digital image-matching algorithms. The algorithms were originally developed for the machine-vision market.

Because of its relative ease of use and ability to generate very high-resolution point clouds and 3D images, SfM is a technology that is positioned to be a game-changer for mapping and model development.

Global Navigation Satellite Systems

Global navigation satellite systems (GNSS) are configurations of orbiting satellites that provide geospatial positioning data to receivers on earth. This technology is widely exploited by common consumer devices such as smartphones and in-car navigation systems. GNSS are also the core positioning technology for advanced highway surveying and automated construction equipment, including real-time kinematic units and automated machine guidance systems.

Currently, two GNSS are fully operable: United States' Global Positioning System (GPS) and the Russian Federation's Global Orbiting Navigation Satellite System (GLONASS). GPS is currently the predominant data source for the Western Hemisphere; however, many newer devices support GLONASS as well. GNSS from other nations are under development, with ongoing international efforts to ensure these systems are interoperable and fully available for civilian applications.

Selecting the Right Tools

With broad and sometimes overlapping capabilities, selecting the appropriate technology for a program is important. One key to success is choosing the tools with capabilities best matched to well-defined program goals. In practice, highway design and construction professionals often use multiple systems together to capitalize on the strengths of each. In addition, these technologies can be coupled with existing systems, such as automated machine guidance and advanced surveying instruments.

Because product size has been reduced and costs are lower, advanced geospatial tools are increasingly available for a wide range of highway design and construction applications. The tools highlighted here are quickly bringing change to a discipline historically characterized by gradual advancement.

Morgan L. Kessler, P.E., is a highway research engineer at FHWA's Turner-Fairbank Highway Research Center.

Geospatial Tools and Applicability to Highway Construction

Application	GNSS	Terrestrial LiDAR	Mobile LiDAR	Aerial LiDAR	Terrestrial Photogrammetry	Aerial Photogrammetry	SfM	UAS
Topographic surveying	✓	✓	✓	✓	✓	✓	✓	✓
Earthwork	✓	✓	–	✓	✓	✓	✓	✓
Paving	✓	✓	✓	–	–	–	–	–
Roadway design	✓	✓	✓	✓	–	✓	–	–
Automated machine guidance	✓	✓	✓	–	–	–	–	–
Verification	✓	✓	✓	–	–	✓	–	–
As-built surveys	✓	✓	✓	–	–	✓	–	–
Site/project monitoring	✓	✓	–	✓	–	✓	–	–
Inspection	✓	✓	✓	–	–	✓	–	–
Quality assurance/quality control	✓	✓	✓	–	✓	✓	✓	✓
Asset management	✓	✓	✓	✓	–	✓	–	–

INNOVATION CORNER

by Tony Furst

Pilot, Playbook, Partnership: Tackling the Workforce Shortage

The highway construction industry is facing a shortage of skilled workers to fill jobs that are too often left vacant. Construction firms say they can fill only 60 percent or less of the open jobs in critical occupations, including heavy equipment operators, cement masons, and iron workers, according to surveys by the Associated General Contractors of America in 2015 and 2018. The worker shortage threatens the safety and efficiency of the highway system by slowing the progress of needed highway projects and delaying benefits to highway users.

To combat threats resulting from the shortage, the Federal Highway Administration's Office of Innovative Program Delivery (OIPD) developed the Roads to Your Future campaign. The campaign provides a customizable approach to hiring that can help overcome the worker shortfall. Roads to Your Future is the result of a collaboration between OIPD, the U.S. Department of Labor, local agencies, and industry.

The Pilot

OIPD, through the Center for Transportation Workforce Development and in partnership with other government and industry organizations, developed a 2-year pilot to help solve the workforce shortage. The pilot included six cities and six States of various sizes and demographics, and concluded in December 2018. The pilot locations experimented with innovative ways to identify, train, and place workers into highway construction jobs.

The Playbook

OIPD captured the successes and challenges from the pilot in a playbook for others to use to build their highway construction workforce. The playbook provides useful practices based on recurring themes from the pilot. The variety of experiences described in the playbook represent efforts from all over the country, and users can tailor the practices to create solutions for any region's needs.

The playbook offers inspiring stories from people like Frank De La Torre, who completed one of the highlighted programs and became a heavy equipment operator.

"The training really changed my life," says De La Torre. "I don't know what I would be doing if I didn't do this."

The playbook also includes best practices for organizing stakeholders, success stories from pilot locations, complete programs ready for implementation, and takeaways on issues others have faced in hiring.

Agencies can learn from examples such as the Arizona Industry Readiness Course. This 1-week training course prepares potential workers for a career in highway construction, covering basic work and life skills required to work in the industry. Trainees also take field trips to highway construction sites to see the real-world conditions they will experience on the job. This program is among several identified in the playbook as proven, scalable, and immediately adoptable by other agencies.

The Roads to Your Future campaign offers free outreach materials like this advertisement to help attract transportation workers. *Source: FHWA.*

The playbook is available at www.fhwa.dot.gov/RoadsToYourFuture.

The Partnership

While the playbook is an important first step, a long-term solution to the workforce problem requires a lasting effort. As a follow-on to the pilot and playbook, FHWA formed the Highway Construction Workforce Partnership—Roads to Your Future. The partnership is a collaboration of national organizations to provide ongoing knowledge, resources, and technical assistance needed to support local hiring efforts.

FHWA and OIPD also provide a collection of free, downloadable Roads to Your Future outreach materials for attracting workers. These materials include print items—posters, flyers, and mailer cards—and digital ones such as social media graphics. Agencies can customize all of the materials with local information.

Through the partnership, FHWA is available to provide direct technical support to help agencies interested in forming a local effort and using the playbook. FHWA will also host peer exchanges, providing opportunities to interact with, learn from, and share ideas with individuals from other locations.

"To take the first step toward addressing your highway workforce needs, read the playbook and connect with the partnership," says Cindi Ptak, managing director of OIPD. "Together, we can transform the way our Nation hires its highway construction workforce."

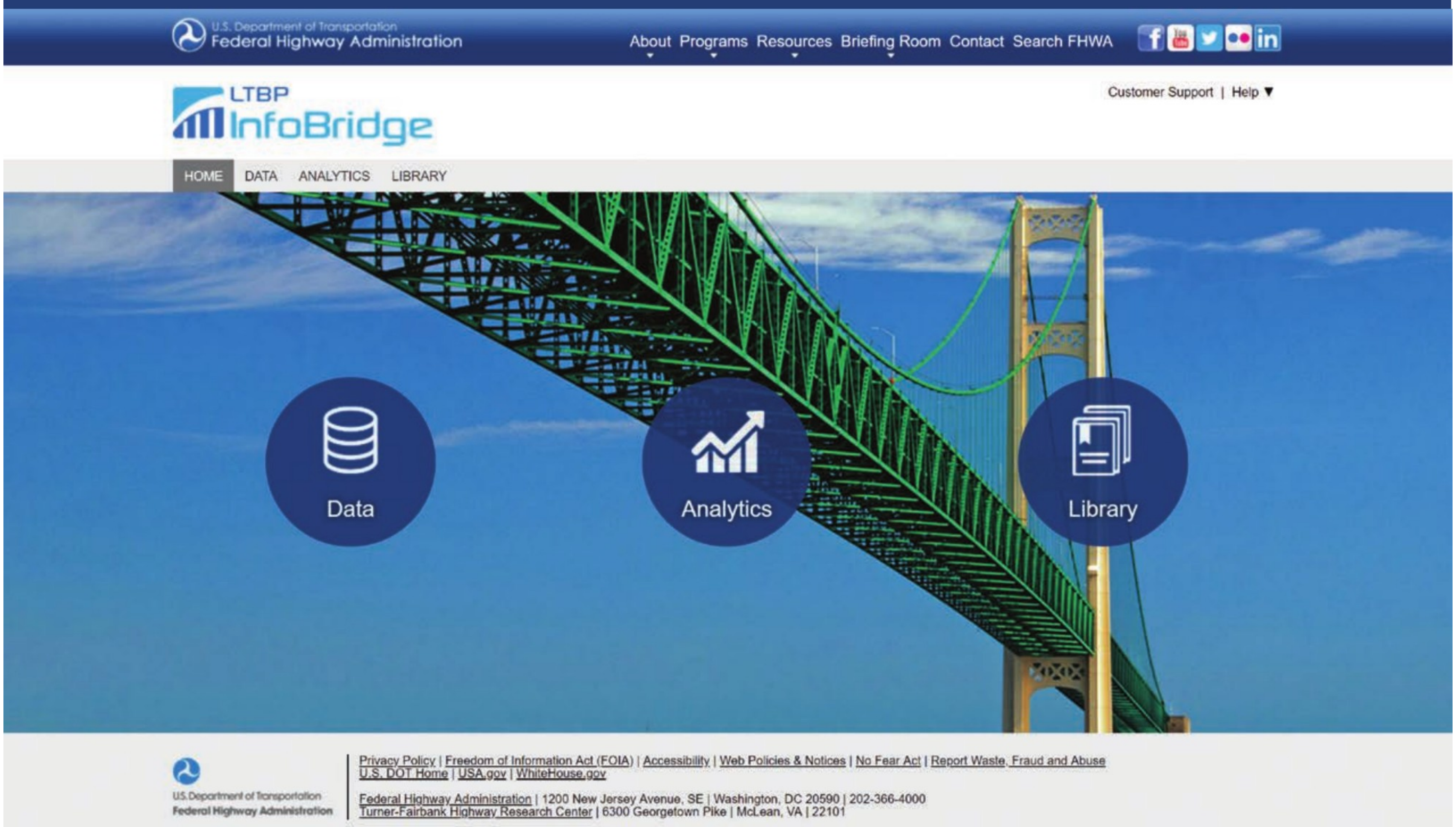
For more information, visit www.fhwa.dot.gov/RoadsToYourFuture.

Tony Furst is FHWA's Chief Innovation Officer.

A New Home for Bridge Data

by Jean Nehme

FHWA's InfoBridge™ is a centralized gateway for efficient and quick access to performance-related data and information.



(Above) The InfoBridge web portal provides site users with a one-stop shop for accessing data, analytics, and a library of other LTBP resources. *Source: FHWA.*

Collecting critical bridge performance data that are not available elsewhere and merging them with data gathered from other available sources is no small task. Providing efficient and quick access to data and information has been an even bigger challenge until now. In January 2019, the Federal Highway Administration's Long-Term Bridge Performance (LTBP) Program released the LTBP InfoBridge™ web portal for dissemination and visualization of data, information, and products it develops. The portal's main purpose is to leverage the analytical capability of the highway bridge research community, and serve as a means of fulfilling FHWA's responsibility to provide transparency and ready access to data collected through Federal research programs.

In addition to providing a trove of bridge performance information for use in research studies, InfoBridge enables bridge owners with limited or no access to bridge asset management software to manage their bridge inventories through a seamless user interface that incorporates state-of-the-art querying and visualization tools. Universities that have bridge engineering curricula can also benefit from InfoBridge because it enables students to access a free platform that is extremely data rich and analytics ready. The portal, available at https://infobridge.fhwa.dot.gov, is cloud-based and does not require user registration or login.

"Our goal at FHWA is to make InfoBridge a comprehensive bridge performance portal, enabling researchers to develop tools and products that will enhance understanding

of the performance of highway bridge assets, and enabling anyone interested in bridge performance to easily access and explore the available information," says Cheryl Richter, Ph.D., P.E., director of the Office of Infrastructure Research and Development at FHWA. "Ultimately, it will lead to more efficient design, construction, rehabilitation, maintenance, preservation, and management of those assets."

Goals of the LTBP Program

The LTBP Program is a long-term research effort to help the bridge community better understand bridge performance. The overall objectives of the LTBP Program are to monitor representative samples of bridges nationwide to collect, document, maintain, manage, and disseminate high-quality quantitative performance data over an extended period of time. The program accomplishes this by taking advantage of advanced nondestructive evaluation and structural health monitoring technologies in addition to traditional visual bridge inspection approaches.

FHWA designed the LTBP Program to collect critical performance data that are not available elsewhere and merge them with data gathered from other available sources. Achieving all its objectives requires the LTBP Program to collaborate closely with State transportation departments, academia, and industry.

The LTBP Program created InfoBridge to provide a user-friendly web portal that includes intuitive tools for finding, viewing, and analyzing bridge performance information. The tool gives users the ability to efficiently share data selections and summary reports.

InfoBridge Modules

The InfoBridge web portal includes multiple tools that facilitate bridge data analytics. It provides for storage, retrieval, dissemination, analysis, and visualization of data collected through State, national, and LTBP Program efforts to provide users with the ability to holistically assess bridge performance on a network or individual bridge basis. What follows is a more detailed look at several of the main components.

Find Bridges. This feature consists of data filter attributes grouped under the categories of National Bridge Inventory (NBI), National Bridge Elements (NBE), and LTBP. This feature enables the user to efficiently query the database and present the results both in a paginated tabular view and on a map. Users can see performance data and statistics on the dashboard. In addition, users have the option to save query and filter criteria for future use.

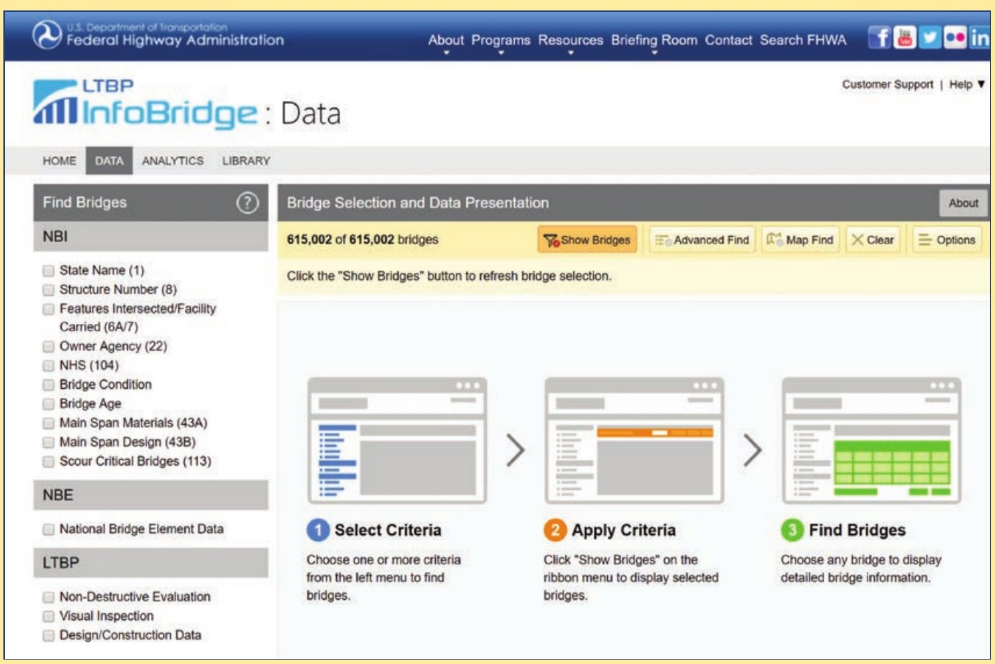
Advanced Find. While the Find Bridges feature works on basic data attributes, the Advanced Find feature enables users to further narrow down their selection criteria by using all data attributes available under different categories. This feature works in conjunction with the Find Bridges feature, and it enables users to apply sophisticated data searches on the underlying bridge data.

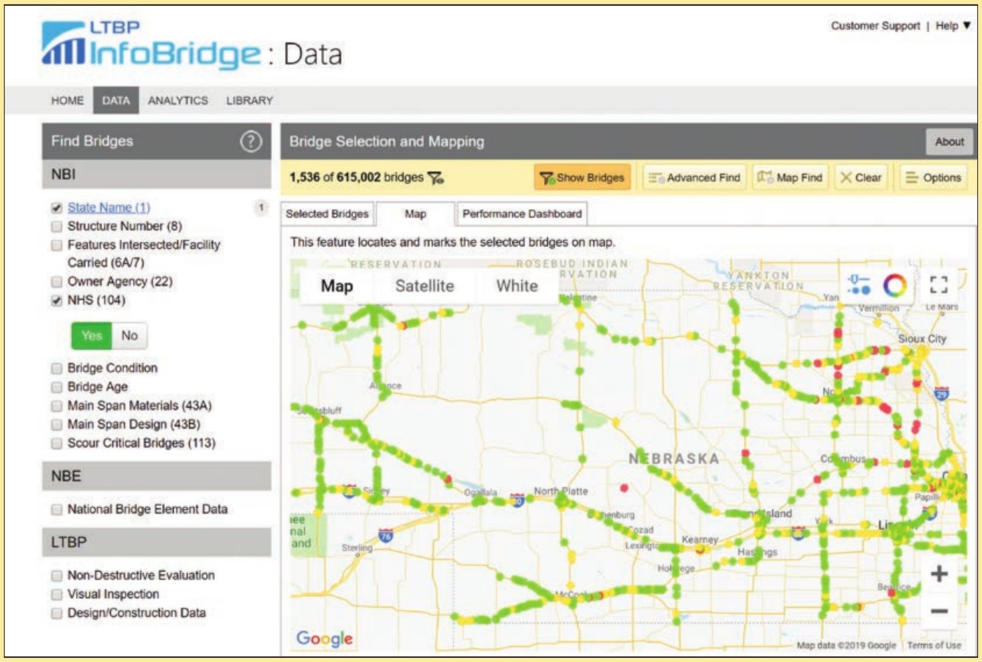
Map Find. The Map Find feature plots the selected bridges on an interactive map. By using drawing tools, users can change the selection criteria and view the results on the map. This feature is useful independently as well as in conjunction with the Find Bridges and Advanced Find features to further refine the selected dataset.

Performance Dashboard. The Performance Dashboard displays bar charts, tabulated summaries, and historical performance graphs corresponding to the selected bridges. It enables users to view performance summaries at a glance. As in all InfoBridge modules, the user can print or download the data displayed on the dashboard.

Bridge Information. Selecting a bridge from the Selected Bridges table or map displays the bridge details under the Bridge Information section. The Bridge Information section is categorized in different

Site users can efficiently query the database by selecting criteria and filtering data to meet their needs. *Source: FHWA.*





InfoBridge search options enable users to find and map bridges and conditions within the criteria they set. For example, this map shows the results of a search for all bridges on the National Highway System located in Nebraska. *Source: FHWA.*

tabs including overview, NBI, NBE, climate, and LTBP tabs. The overview tab displays the key data attributes and overall extent of the data availability for the selected bridge. The remaining tabs provide access to the bridge data for the corresponding data category. This feature also provides the ability to generate a bridge report per NBI submittal year for the selected bridge.

Visualize Bridge Data. Different visualization options are available for reviewing and analyzing bridge data. Graphs and charts depict historical bridge condition data, bridge component deterioration modeling, and climatic data. LTBP Program bridges have additional data associated with them such as nondestructive evaluation results and design/construction information. Innovative visualization techniques model bridge component deterioration interactively.

Analytics. The Analytics feature enables researchers to use the extensive bridge performance data contained within InfoBridge to view, develop, and improve forecasting models for bridge performance. While the focus of data analysis is on understanding the past, data analytics focuses on the discovery, interpretation, and communication of meaningful patterns in data. InfoBridge offers state-of-the-art tools and techniques that enable users to apply data analytics to bridge performance data.

Library. The Library provides access to LTBP Program products and publications. Included are LTBP protocols for establishing a consistent methodology covering the planning, field collection, and postprocessing of bridge performance data. In addition, historical changes in bridge materials and design specifications are displayed in chronological order.

Help. The Help feature consists of the sitemap and frequently asked questions sections. In addition, it contains a Customer Support Request page, enabling users to submit questions and provide feedback to the LTBP Customer Support Service Center.

The Future of InfoBridge

FHWA expects to implement major enhancements to InfoBridge over the next few years. Many enhancements—for example, augmenting the number of the available fields to query the data, improving the chart capabilities, enabling users to dynamically design the layout of the "Selected Bridges" table, and implementing bridge deck deterioration models—are already in the works, and others will be based on feedback from the user community.

"Maintaining the data and tools that constitute InfoBridge is a major challenge that we plan to confront as long as the benefits to our stakeholders justify our efforts," Richter says.

In addition to updating InfoBridge NBI data annually and increasing the amount of the research-quality data that it is collecting through the LTBP Program, FHWA also will continue to explore incorporating data collected by others when appropriate.

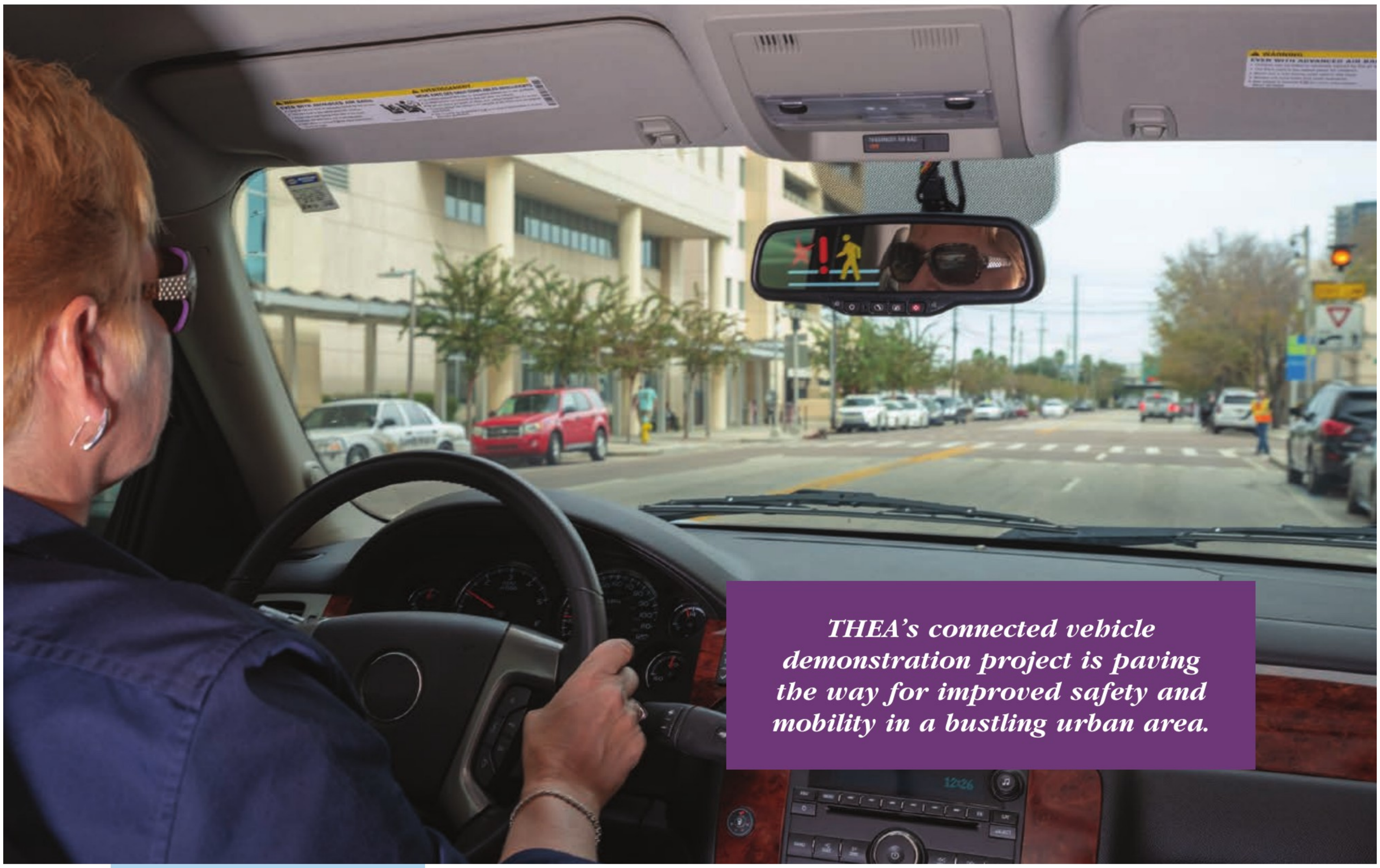
Jean Nehme, Ph.D., P.E., is team leader of FHWA's Long-Term Infrastructure Performance programs. He oversees the Long-Term Pavement Performance Program and the LTBP. Nehme joined FHWA in 2017 after a 26-year career at the Arizona Department of Transportation where he held various positions including State bridge engineer, State asset management engineer, and director of performance management and research. He holds bachelor's, master's, and Ph.D. degrees in engineering from the University of New Mexico. He is a licensed professional engineer in Arizona.

For more information, see https://infobridge.fhwa.dot.gov and https://highways.dot.gov/long-term-infrastructure-performance/ltbp/long-term-bridge-performance or contact Jean Nehme at 202–493–3042 or jean.nehme@dot.gov.

FOCUS ON—CONNECTED VEHICLES

Transforming Transportation in Tampa

by Govindarajan Vadakpat, Kate Hartman, Robert Frey, and Edward Fok



THEA's connected vehicle demonstration project is paving the way for improved safety and mobility in a bustling urban area.

A driver receives a warning about the presence of a pedestrian in the vehicle's predicted path in the rear-view mirror of a car equipped with CV technology in Tampa, FL. Pedestrian safety is one of the main goals of the Tampa CV pilot. © *THEA.*

Connected vehicles (CV) are poised to transform the Nation's streets and communities and have the potential to improve safety and mobility. In Tampa, FL, these emerging technologies may help to revolutionize transportation in the multimodal downtown area while mitigating issues such as traffic congestion and delays, vehicle crashes, pedestrian safety, and transit conflicts.

In a competitive process in 2015, the U.S. Department of Transportation selected the Tampa Hillsborough Expressway Authority (THEA) in Tampa as one of three pilot sites—along with sites in New York City and Wyoming—for deployment of CV technology. The goals of the CV Pilot Deployment Program are to determine what barriers exist and how to address them, document lessons learned, and serve as a template to assist other early technology deployments.

USDOT awarded THEA $17 million as part of its pilot deployment program.

This map shows the pilot deployment area, indicated by a red box and an arrow, in relation to the surrounding area, including nearby interstates and THEA's Selmon Expressway and Reversible Express Lanes. © *THEA.*

Currently, the three-phased pilot deployment project is in the final operations and maintenance phase. The project uses vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-everything connected technology.

"The goal of the Tampa CV pilot," says Joe Waggoner, executive director of THEA, "is to transform the experience of drivers, transit riders, and pedestrians in the downtown Tampa area by preventing crashes, enhancing traffic flow, improving transit trip times, and reducing emissions."

Tampa's Multimodal Pilot Site

Downtown Tampa is bordered by the Ybor Channel, which serves cruise ships and a commercial port, to the east; Garrison Channel, a local waterway, to the south; Florida Avenue to the west; and Scott Street to the north. A virtually flat topography near sea level helps to simplify the evaluation of traffic flow parameters. THEA owns and operates the Lee Roy Selmon Expressway and the elevated Reversible Express Lanes (REL), which run parallel to one another and provide vehicle access to the downtown area.

The REL is an all-electronic toll facility that serves as a main commuter route, connecting the large residential community of Brandon and I–75 with downtown Tampa, the Port of Tampa Bay (serving commercial and cruise ships), and MacDill Air Force Base. REL traffic exits at the intersection of Twiggs Street and Meridian Avenue in downtown.

The morning commute on the REL ends in the heart of the central business district, and drivers often experience significant delays during the morning peak rush hour. These delays are caused by the traffic light at the end of the limited access highway and can result in rear-end crashes and collisions caused by red-light running. Because the lanes are reversible, wrong way entry is also possible.

The Selmon Expressway provides ingress and egress for downtown traffic, as well as traffic going to and from Pinellas County to the west. In addition, the westernmost exit is at Dale Mabry Highway, the location of the main gate for the Air Force base. Since September 2010, all vehicles on the expressway are tolled electronically as they pass under toll gantries.

The area targeted by the deployment pilot is multimodal. Hillsborough Area Regional Transit bus lines run through the area, and express routes use the Selmon Expressway to serve commuters from the Brandon area. The Marion Transit Center is in the northwest section of the pilot focus area, near I–275. It also serves other express bus routes. The TECO Line Streetcar System extends through the project area, serving local businesses and the Amalie Arena, which frequently generates traffic from sporting and special events. Meridian Avenue is a major gateway to downtown Tampa and feeds the REL. It is the focal point for several of the pilot's applications, such as wrong way driving and speed reduction warnings. Channelside Drive, on the east and south borders of the test area, connects to Amalie Arena.

Locations with high volumes of mixed traffic, such as that found within the focus area in Tampa, offer greater potential for conflicts between streetcars, pedestrians, and passenger cars.

Pilot Objectives

The diversity of modes—bus and streetcar transit, highway and surface street interfaces, and a high density of pedestrians—in a concentrated area of downtown Tampa provides many traffic situations in which THEA can test CV technology for effectiveness. The broad goals of the THEA pilot project included developing and deploying CV infrastructure to support CV-based applications, improving mobility within Tampa's central business district, improving safety and reducing environmental impacts within the pilot deployment area, increasing agency efficiency, and developing an environment to help sustain businesses.

"A focused 12-month effort helped distill these broad objectives into six specific use cases to address key issues of the project, and that will help measure the benefits of deploying CV technology," says Steve Novosad, a systems management lead at HNTB.

Use case 1: Morning backups. To address safety- and mobility-related issues of travelers exiting the REL, THEA developed four applications: end-of-ramp deceleration warning, emergency electronic brake light

The pilot team identified appropriate CV applications for six key use cases: morning backups (rush hour collision avoidance), wrong-way entry, pedestrian safety, transit signal (bus) priority, streetcar safety, and traffic progression (flow optimization; two locations). The circles within the highlighted areas represent roadside units that enable wireless communications between infrastructure and onboard vehicle units. *© THEA.*

warning, forward collision warning, and intelligent signal control.

Use case 2: Wrong-way entries. Three applications address safety issues surrounding vehicles entering the REL going the wrong way: wrong-way entries, intersection movement assist, and intelligent signal control.

Use case 3: Pedestrian conflicts. To address pedestrian safety issues at a marked mid-block crossing at Hillsborough County's Edgecomb Courthouse, THEA deployed pedestrian collision warning.

Use case 4: Transit signal priority. Three applications provide priority for buses that use major routes within the central business district: intelligent signal control, intersection movement assist, and transit signal priority.

Use case 5: Streetcar conflicts. To minimize conflicts between TECO Line streetcars and vehicles, THEA deployed the application warning against vehicles turning right in front of a transit vehicle.

Use case 6: Traffic progression. THEA uses intelligent signal control to address traffic congestion along Meridian Avenue during the morning peak travel period.

Facing Challenges

By nature, pilot projects come with technical, institutional, and financial challenges. Discovering and addressing these concerns is one of the main reasons to run a pilot program. THEA's deployment pilot was no exception and faced a variety of challenges. Details of several of the Tampa team's challenges and solutions follow.

Maintaining a strict separation between networks. As a toll road operator, THEA collects data on toll transactions and sends data to relevant vendors for collection of the tolls. To make sure that customer data was not accessible to outside networks, it was critical to maintain a strict separation between revenue-generating toll data and CV pilot data. To ensure complete separation of tolling network data and data generated by the CV pilot, THEA invested in upgrading its information technology equipment.

Availability of technical personnel for device installations. Piloting cutting-edge technology means a lack of professionals trained to install or service the equipment. Because the THEA pilot involved installing equipment in vehicles owned by private drivers, the team had to ensure that the installations were done in a professional setting with certified vehicle mechanics.

THEA established a partnership with nearby Hillsborough Community College to use the college's facility and staff to oversee installation by students in its master mechanic program. This symbiotic relationship turned out to be a win-win for both THEA and the community college by reducing labor costs for installation and giving the students real-world mechanical experience with this exciting new technology.

Flexibility to perform live on-road testing. Real-world testing

Downtown Tampa's multimodal traffic, including streetcars and buses, creates conflict points between private vehicles, transit vehicles, and pedestrians. *© THEA.*

Events at Amalie Arena and other attractions in Tampa's CV pilot demonstration area can cause significant traffic delays. © *THEA.*

is an essential element of pilot programs but can be difficult to accomplish because of safety concerns. Because the REL serves the same area as the Selmon Expressway, THEA was able to close the REL during nonpeak hours for onroad testing. This enabled the team to conduct tests of the system deployed in private vehicles safely in a real-world environment.

Radio frequency interference. The Federal Communication Commission allocates the 5.9 GHz radio band for intelligent transportation systems (ITS) applications, but the band is not immune to interference from amateur radio operators under auxiliary licenses. During the deployment testing, THEA encountered this type of interference.

THEA worked with the Florida Department of Transportation, which is the primary license holder, to mitigate the interference from the amateur radio operators. THEA will have to continuously monitor its spectrum to flag potential interference, which might negatively impact the pilot deployment.

Addressing Security And Privacy

Beyond the challenges already identified, security and privacy related to the CV technology presented huge hurdles. THEA's project team recognized that the security requirements of the CV technology needed to extend to the agency's networks and computer systems, and would likely require changes to existing systems and operations. To address these security needs, the pilot team made several changes to THEA's security procedures regarding operations, communications, and maintenance.

Security improvements to operations included increased password control (strength) and expiration, enhanced security for physical access to facilities such as traffic management centers, and improved encryption of databases. To improve communications, the team upgraded the ITS environment, including virtual private network tunnels, datagram transport layer security protocols, and disabling local access ports without security. THEA also implemented the authentication of field personnel in real time when replacing failed devices and required keypad interactions to use USB access ports to reload and initialize devices.

In addition to system security, THEA recognized the importance of maintaining the privacy of the participants in the pilot. One key requirement of USDOT's deployment program was that the data generated during the operational phase of the three pilots would be stored and shared with independent evaluators and researchers. The Tampa pilot team created extensive data sanitization processes that removed personally identifiable information.

Partnering for Success

The busy area chosen for the pilot deployment necessitated communication and coordination among many agencies and entities. Stakeholders include Hillsborough County, Amalie Arena, Tampa Police Department, Florida Highway Patrol, Hillsborough County Sheriff's Office, MacDill Air Force Base, Tampa Port Authority, Tampa Convention Center, Tampa Downtown Partnership, and the Tampa Bay Lightning (the city's professional hockey team). All of these could be directly affected by the pilot deployment project because of the impact of transportation on their operations.

Because of the large number of stakeholders involved in the project, perhaps the most challenging aspect was communicating to diverse groups and coordinating between them. The Tampa CV pilot team built a cadre of professionals to engage in outreach with and education of the stakeholders to gain support critical to the success of the project.

THEA is a self-financing agency that relies entirely on toll revenues. Therefore, the team first needed to explain how the emerging technology could play a larger role in the operations of the agency and then secure commitments from its Board of Directors. Joe Waggoner, THEA's chief executive officer, played a key role in championing the project and also was able to enlist the support of local lawmakers to advocate for the project.

"This award is a game-changer," says Waggoner. "ACES technologies—automated, connected, electric, and shared—are the cutting-edge future of transportation. This CV pilot will positively impact the people of Tampa by ensuring that new technologies preserve pedestrian safety, while improving traffic flow and reducing congestion."

To meet stakeholders' expectations, the team developed memoranda of understanding that clearly spelled out the roles and responsibilities for each party involved. For example, Tampa's traffic management center is co-located with THEA's traffic management center. The addition of new infrastructure at signalized intersections maintained by the city of Tampa and additional capabilities established at the traffic

management center created a need to establish the roles and responsibilities as the project moved into its operational phase. THEA and the city of Tampa signed an agreement detailing the arrangement.

The team also needed to develop data governance management policies and communicate them to potential participants. Developing a strong informed consent document during the participant recruitment and training stage proved to be immensely helpful in communicating how the data generated from the pilot would be used.

Many stakeholders were interested in the possibility of future applications of CV technology in Tampa to improve the long-range fiscal sustainability of the city. As part of the CV pilot program, THEA has installed critical roadway infrastructure that will not only cater to the immediate mobility and safety needs of Tampa, but also enable future efforts to increase mobility, especially within the context of mobility as a service.

CV technology can also provide an open framework for urban parking applications, both identifying open spaces and paying for parking through the system. Through the CV platform, drivers with properly equipped vehicles could find, reserve, access, and pay for parking as they approach an urban area. Third-party providers could offer different quality or price incentives for different locations, integrated with the vehicle's navigation system to provide directions to the parking facility or spot, and provide merchant or restaurant discounts, parking validation, or other perks.

Current Status And Next Steps

Since successful completion of phase 1 (planning) in September 2016, the THEA pilot team has been diligently working on designing and building the CV system. To date, THEA has installed more than 45 roadside units and equipped more than a 1,000 privately owned vehicles, buses, and streetcars with onboard units.

The team successfully demonstrated the overall system as part of the CV Pilot Showcase on November 29, 2018. The highlights of the showcase included demonstration of applications focused on streetcar, bus, and pedestrian safety.

The system is scheduled to go live in July 2019 and will collect operational data throughout 2019. THEA will make the data available to researchers worldwide through the ITS Data Hub at https://www.its.dot.gov/data.

"Operational data collected by the Tampa CV pilot and lessons learned from inception to operation will be instrumental to advancing the technological and intuitional readiness of connected vehicle safety systems," says HNTB's Novosad. "Advancing understanding in these areas will smooth the way for the next group of deployers."

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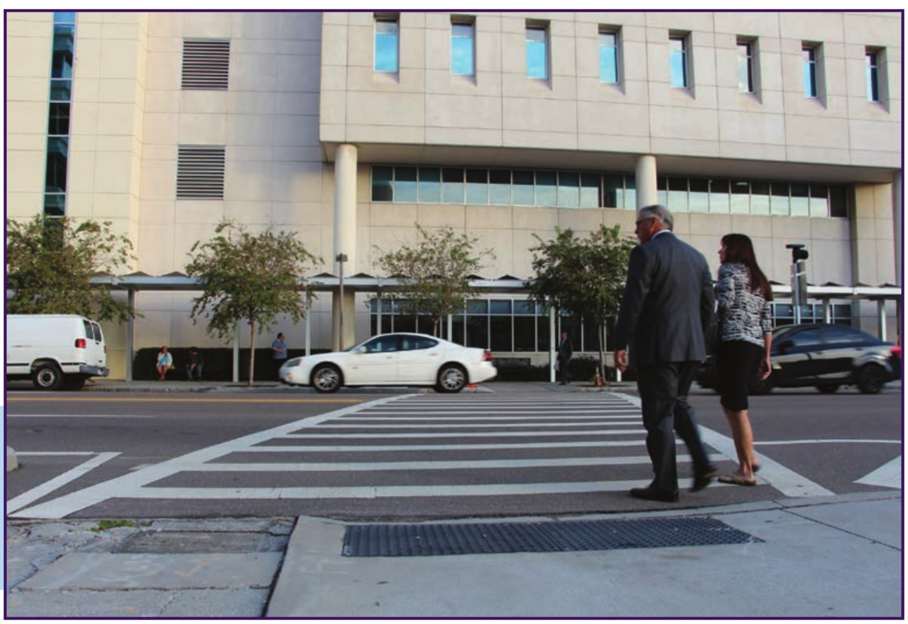
Robert Frey serves as the planning director for THEA and is the project manager for THEA's USDOT CV Pilot Deployment. He has more than 25 years of experience working with local, State, and toll agencies. He holds a master of public policy degree from Baylor University and is a member of the American Institute of Certified Planners.

Edward Fok is a transportation technology specialist in FHWA's Resource Center, where he focuses on assessing emergent technologies for opportunities and risk for surface transportation. He has B.S. degrees in mechanical engineering and electrical engineering.

For more information, see www.its.dot.gov/pilots/index.htm and www.tampacvpilot.com or contact Govindarajan Vadakpat at 202–493–3283 or G.Vadakpat@dot.gov.



To get to the Edgecomb Courthouse, pedestrians must use a mid-block crossing that increases the likelihood of conflicts with vehicles. *© THEA.*

When Atlanta's I–85 bridge catastrophically collapsed, Federal and State transportation agencies joined forces with contractors and suppliers to rebuild in record time.

by Marc Mastronardi

Partnering in a Crisis

During the evening rush hour on Thursday, March 30, 2017, a major freeway bridge in Atlanta, GA, collapsed because of a fire. The viaduct section of I–85 over the vicinity of Piedmont Road succumbed to intense heat fueled by burning high-density polyethylene and fiberglass conduit stored under the bridge. A man was witnessed trespassing in the secured area and was charged with setting the materials on fire. The prestressed concrete girders of one bridge span ultimately collapsed under the load of the structure as the heat caused delamination, or separation, of the concrete and compromised its steel reinforcements. Thankfully, despite the fire and collapse occurring during a peak travel time, no one was injured or killed.

Hours later, the smoke had mostly cleared, enabling bridge inspectors and design engineers from the Georgia Department of Transportation (GDOT) to assess the full damage caused by the fire. Not one, but six spans—three in each direction—were beyond repair. In all, 350 feet (107 meters) of 80-foot-wide (24-meter-wide) structure was lost in both the northbound and southbound lanes of I–85. Officials would have to detour traffic on one of Georgia's busiest corridors through Atlanta for an unknown period of time.

Because I–85 in this location normally carries more than 243,000 vehicles per day, officials realized immediately they were dealing with a traffic nightmare. As GDOT responded to the unfolding regional transportation crisis, the media and the public speculated that it would be many months before the bridge would be back in service.

GDOT and its partners beat the odds, reopening the bridge in an astounding 43 days.

(Above) The media and the public speculated that rebuilding Atlanta's I–85 bridge, which collapsed after materials stored under the bridge caught fire in March 2017, could take months. It took less than 7 weeks. *© GDOT.*

A Collaborative Focus

GDOT's emergency response efforts began minutes after the fire was discovered. "Within hours of the incident, a collaboration of stakeholders and partners was working to launch traffic management efforts, demolition strategies, and retrofit concepts," says Meg Pirkle, P.E., GDOT's chief engineer.

A famous quote attributed to President Harry S. Truman says, "It is amazing what you can accomplish if you do not care who gets the credit." This dynamic—everyone focused on getting the job done, not the credit—helped make the bridge collaboration a success. GDOT Commissioner Russell McMurry's mobile phone was quickly overwhelmed with texts and calls from those offering assistance as the event unfolded. Many of GDOT's senior staff experienced the same thing. Team members heard from elected officials, many of Georgia's State agencies, leadership from the Federal Highway Administration's Georgia Division, State and local transit operators, contractors within and outside of Georgia, materials suppliers, private consulting engineers, countless vendors, and many more—none of whom sought the spotlight.

GDOT maintains an emergency operations site within its Transportation Management Center east of downtown Atlanta. Key personnel began to gather there, even without direction to do so, as news spread of the fire and subsequent collapse.

Recently retired FHWA Georgia Division Administrator Rodney Barry, P.E., arrived mid-evening to offer his expertise and knowledge of emergency responses and contracting. Like one of the team, he joined GDOT staff who were already working to triage the collapse, develop detours, coordinate with transit operators for route alterations, optimize traffic signalization,

As emergency responders extinguished the flames, GDOT's contractor was already working to provide signage and barricades for traffic control. *© GDOT.*

deploy electronic messaging across GDOT's network, and provide critical communication to the media.

Barry's quick assessment that the significance of the freeway disruption warranted a quick release of emergency response funding and a negotiated contract procurement process, where a contractor is identified and a contract price is negotiated in lieu of a competitive bid, under the provisions of FHWA's *Emergency Relief Manual,* kick-started the rebuild project. A traditional competitive bid process that included design, review, advertisement, letting, and award would have had added significant delay.

Partnering for Speed

Partnering is a shared understanding of the importance of the project while assuring respect for each partner's roles and commitment to delivery. FHWA encouraged e-construction and construction partnering as part of the fourth round of the Every Day Counts initiative. Construction partnering is a project management practice where transportation agencies, contractors, and other stakeholders create a team relationship of mutual trust and improved communications. Benefits include increased transparency, decreased time to delivery, and reduced costs.

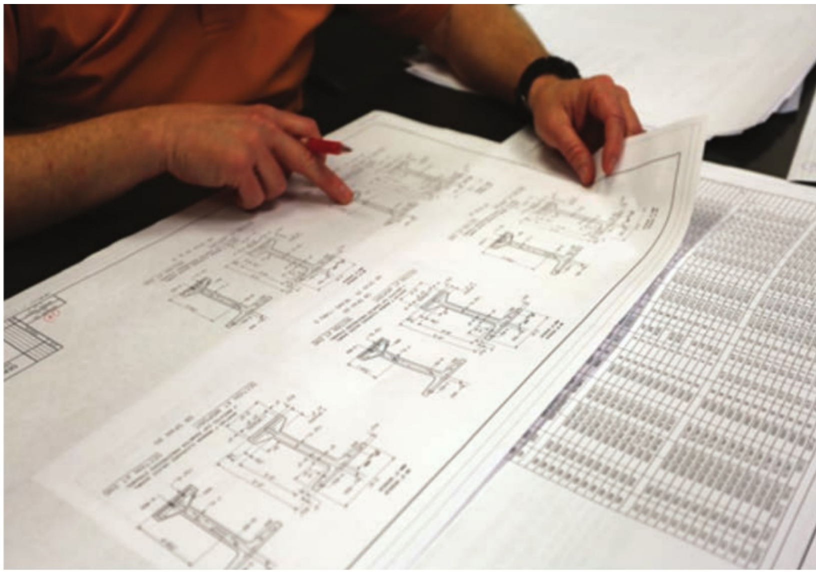
For GDOT, partnering has become a staple practice because of its increasing use of public-private partnerships and innovative contracting efforts. With this strong background, GDOT was able to leverage an existing partnership to respond quickly to the I–85 bridge incident. Many qualified and capable contractors reached out to GDOT on the night of the collapse to assist, including C.W. Matthews Contracting Company, Inc. (CWM), with whom GDOT had an active project north of the site. CWM was able to provide immediate assistance with detour implementation.

After a single phone call, the contractor provided signage, barricades, and subcontracted striping services for traffic control needs. As the company worked to implement GDOT's plans, it would contact the department to confirm details with an email sketch or a text, demonstrating a commitment to collaboration.

As the night progressed, the magnitude of the damage emerged. Contracted personnel onsite installed temporary traffic control devices, giving their experts the opportunity to consider demolition strategies and contact GDOT to determine available crews and equipment—more collaboration on the short-term needs of what was not yet an official project. Simultaneously, GDOT staff developed strategies to quickly and efficiently move forward by recalling past fires, floods, and other incidents for perspective. GDOT's bridge engineers pulled archived bridge plans to help with the preparation of reconstruction plans.

Within a few hours of the collapse, GDOT staff approached Commissioner McMurry to suggest that of four firms being considered, engaging CWM on the rebuild immediately would be most feasible and advantageous because the contract could be negotiated at a reasonable price with a single contractor rather than being put up for competitive bidding. In addition, CWM and GDOT had experience working together on a similar emergency: the replacement of an interstate bridge deck following a tractor trailer fire on I–285 in Atlanta in 2001. The contractor had crew availability, was already assisting with detour implementation, and had ideas and resources to begin demolition immediately. Because of these factors, GDOT decided to proceed with CWM as the contractor, even though

Demolition of the damaged spans began just hours after the fire was extinguished. *© GDOT.*



Teams of engineers and designers worked around the clock in the days after the collapse to prepare plans for the bridge replacement. *© GDOT.*

the project was not yet fully scoped.

In the early hours of Friday, March 31, CWM subcontracted D.H. Griffin Companies for demolition services. Demolition of the six spans began that morning—less than 24 hours after the fire. Partnering in crisis began in earnest.

Plans and Incentives

The morning after the fire, U.S. Secretary of Transportation Elaine Chao announced the release of $10 million in emergency repair funds following State and Federal declarations of emergency.

Over the course of the weekend, bridge designers worked to redesign the spans, including a retrofit of 61 bulb-tee beams to replace the original Type 5 girders. The project required the custom design of individual beams because of the horizontal curve of I–85 passing over Piedmont Road, creating bridge spans in a trapezoid shape in each direction. To tackle this task and other elements necessary for the reconstruction plans, 15-member bridge design crews worked in alternating shifts throughout the weekend under the oversight of Bill DuVall, P.E., the State bridge engineer. As GDOT and the contractor coalesced into a design-build team, they exchanged preliminary plans, refined them, developed shop drawings, and solicited quotes from vendors.

GDOT leveraged incentives to complete the work as expeditiously as possible. "[Then] Governor Nathan Deal asked GDOT how we could employ private sector principles to ensure the work was done as fast as possible and that was where we began evaluating incentives," says Commissioner McMurry.

The agency employed a road user cost analysis to establish those incentives. Using an average daily traffic figure of 243,000 vehicles, the detoured travel time compared to the open freeway travel time, and the input adjustments typically made for expected distribution, GDOT conservatively estimated the impact of the collapse and repairs to be $850,000 per day. The agency estimated the total cost of the rebuild to be $12 million, and the team determined an aggressive but achievable goal for project completion prior to June 15, 2017.

Representatives from GDOT, FHWA's Georgia Division, and the contractor met on April 7 to negotiate the contract. After three rounds of considerations, the group agreed to an itemized contract for a total of almost $12 million and a tiered incentive structure. The final contract provided a $2 million incentive if work were to be completed by May 21, with an additional $200,000 per day for earlier completion up to a maximum of $3.1 million. However, GDOT added a provision that if all work were completed by May 25, the contractor would still receive an incentive of $1.5 million. The contract also included a disincentive of $200,000 per day beyond June 15.

As it turned out, the incentives—and commitment to partnership—worked, and the project maintained a 24/7 schedule throughout the rebuild. The bridge reopened to traffic on Saturday, May 13, only 43 days after the collapse.

Exceeding the Goal

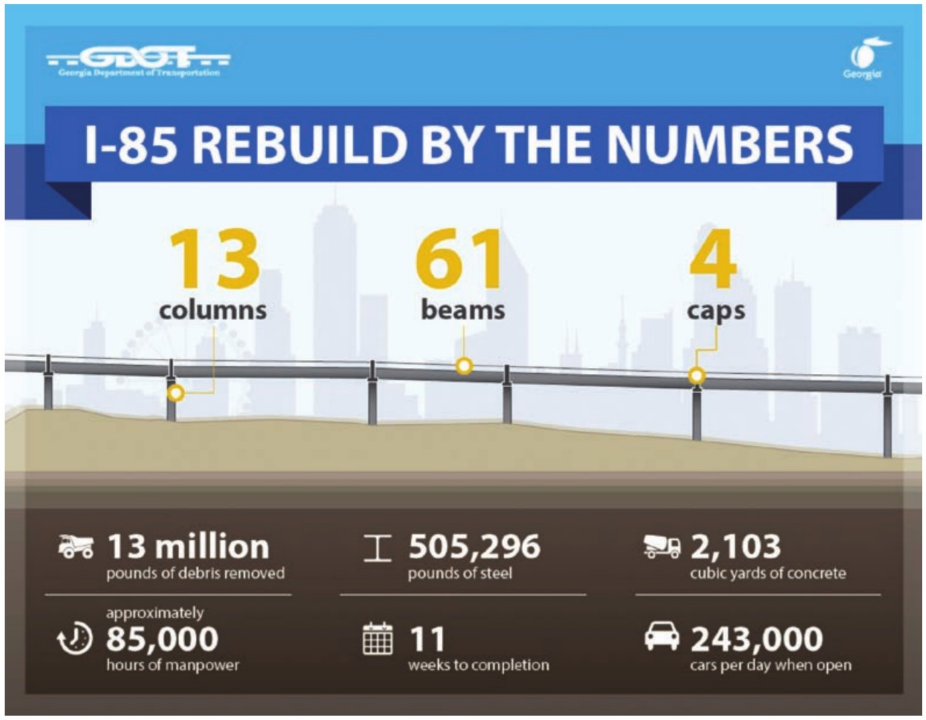
To maintain the aggressive schedule, the project team needed to manage multiple activities concurrently. During demolition, which was conducted and paid for separately from the rebuild, CWM and its concrete mix supplier began working hand-in-hand with GDOT to develop mix designs starting on April 4. Specimen testing began on April 5. Demolition crews completed their work on April 7, hauling away the last of 13 million pounds of charred material from the site. Underscoring the urgency of the rebuild, onsite crews completed the first column pour with the approved concrete mix that same evening. They were fortunate to be able to retain portions of the original columns and encase them in

GDOT and CWM supported the project with onsite experts to ensure smooth communications and quick responses throughout the rebuild. *© GDOT.*

new concrete, saving time.

GDOT staffed the rebuild with two bridge construction engineers from its Construction Division. Each worked alternating 12- to 14-hour shifts to provide onsite subject matter expertise at all times. The lead engineers also supervised teams of 8 to 10 consultant engineering inspectors per shift. With this onsite support and an extended network of senior GDOT and contracted staff committed to the success of the rebuild, decisions needing higher level review were escalated and resolved within minutes.

"With concurrent activities advancing the construction, scheduling was based not on days, but hours," says Adam Grist, vice president of structures at CWM. "Practicing real-time coordination and joint project ownership was vital to managing such an intensive schedule without sacrificing quality."



© GDOT.

On April 17, 2017, 18 days after the fire, crews set beams on one span in each direction. They installed all 61 beams by April 25. Deck pours began on April 27. Crews completed all northbound spans by May 1 and all southbound spans by May 5. The team also carried on with work on ancillary items including traffic barrier walls, striping, hardware replacement for intelligent transportation systems, and repairs to Piedmont Road.

In yet another layer of concurrency and partnering, GDOT took the opportunity to coordinate asphalt mill and inlay work of an already planned, separate project on I–85 near the viaduct. This enabled GDOT to complete the additional work while I–85 was closed for the bridge repair, avoiding having to hamper travel again shortly after reopening the bridge.

A Partnering Success

GDOT and its partners opened the vital north-south link on Saturday, May 13, 2017, a mere 43 days after the fire. Including demolition and incentive, the total cost of the rebuild was $16.6 million. Compared to the cost of diverting road users to detour routes, GDOT estimated the value of the return on the incentives at approximately $27 million.

While the weather was on their side—only half of one shift was lost to inclement weather—the project's success primarily came from the partnership and commitment from all involved, as well as GDOT's willingness to use innovative contracting methods.

The success of the rebuild brought praise to GDOT, FHWA, the contractors, and their many partners involved in the project. Secretary Chao and members of her staff took part in a ceremonial ribbon cutting on May 18, 2017, to celebrate the rapid reconstruction. In her remarks at the event, the Secretary recognized that building a bridge "in [fewer] than 7 weeks is a marvel of dedication, engineering, and teamwork."

Marc Mastronardi, P.E., M.ASCE is a 26-year veteran of GDOT construction and is currently the agency's director of construction. Mastronardi played a significant role in the I–85 rebuild and remains proud of being part of the team that collaborated to exceed customer expectations.

For more information, see www.dot.ga.gov/BuildSmart/Projects/Pages/I85Bridge.aspx#tab-2 or contact Marc Mastronardi at 404-631-1970 or mmastronardi@dot.ga.gov.

Transportation Secretary Elaine Chao praised the work of the project's partners during a ceremony celebrating the reopening on May 18, 2017. *© GDOT.*

From Farm to Table

by Chip Millard

Moving food and other agricultural products within the United States and also between countries presents many challenges and opportunities for the transportation industry.

Most people are very good at handling the last 1.5 feet (0.45 meters) of the food supply chain—that is, eating the food that they consume at home or at a restaurant. However, they do not give much thought to how the food they eat gets to grocery stores and restaurants. The agriculture supply chain is a complex system involving various types of grain, fruit and vegetable, dairy, and meat products. Products are imported from other countries; transported from numerous regions within the United States; and distribution networks between food producers, stores, and end consumers.

Agriculture is a booming business in the United States and internationally, and the process by which food products get from their production location to consumers' dinner plates is complex and ever-evolving. *zych © 123RF.com.*

Agricultural production is a big business in the United States—everyone needs to eat. According to the U.S. Department of Agriculture (USDA), agriculture, food, and related industries contributed $992 billion to the U.S. Gross Domestic Product (GDP) in 2015, which is 5.5 percent of the overall U.S. GDP. In addition, many jobs are tied to the agricultural sector. In 2017, a total of 21.6 million full- and part-time jobs were related to the agricultural and food sectors, which is 11 percent of the total U.S. employment.

How do all of the various aspects of food supply chains work? Read on for insights into how agricultural products are produced and transported from production locations to stores, restaurants, and—in this age of e-commerce—directly to end consumers' homes.

Imports and Exports

The United States exports and imports significant volumes of food. The globalization of food production broadened the types of products that are available to all consumers, made many seasonal food products available at all or most times throughout the year, and significantly reduced the threat to food availability posed by droughts, floods, and

other naturally occurring events that negatively impact food production.

According to USDA, U.S. agricultural exports equaled about $140 billion in 2018, and the export share of U.S. agricultural production is about 20 percent of total production. Horticultural products (for example, fruits, vegetables, tree nuts, wine, essential oils, and other similar products), grains and feeds, and livestock products account for the largest share of U.S. agricultural exports. More than 70 percent of the tree nuts and cotton and greater than 50 percent of rice and wheat produced in the United States are exported.

In contrast with exports, U.S. agricultural imports totaled approximately $129 billion in 2018. Horticultural products, sugar, and tropical products (for example, coffee, cocoa, and rubber) accounted for nearly two-thirds of imports. In terms of percentage of imports to total consumption by food category, more than 95 percent of the coffee, cocoa, spices, fish, and shellfish; about 50 percent of fruits and fruit juices; and more than 30 percent of the wine and sugar consumed in the U.S. are imported.

U.S. agricultural exports and imports have grown significantly in recent years—both have more than doubled in monetary value terms between 2004 and 2018. Advanced refrigeration processes and techniques have played a major role in the expansion of food trade, along with more efficient transportation systems. These factors have enabled large farmers and other food producers to increase their market reach and helped more countries to become integrated into global food supply chains.

Large food distribution companies have taken advantage of greater market access. Increasingly, they have become able to efficiently distribute food around the world, lowering the cost of food for most consumers while also increasing the variety of food available.

Food Trade Patterns

U.S. food trade patterns reveal that Canada and Mexico are the leading sources of U.S. agricultural imports, while China, Canada, and Mexico are the largest U.S. agricultural export markets. Those three countries are also the United States' largest overall trade partners for all products. However, most U.S.-China trade is focused on imports from China while U.S.-Canada and U.S.-Mexico trade patterns are much more balanced.

In 2016, the U.S. exported $38.1 billion in agricultural products to Canada and Mexico. Those exports accounted for 28 percent of the United States' total agricultural exports. By contrast, during the same year the United States imported $44.5 billion in agricultural products from Canada and Mexico, or 39 percent of the United States' total agricultural imports. The somewhat higher value of imports than exports was a reversal of trends from earlier in the decade. The strong U.S. dollar, which makes U.S. exports more expensive in other countries and imports less expensive in the United States, played a role in the increased value of imported products.

Leading agricultural trade products between the United States and its neighbors include meat, dairy products, grains and feed, fruits, tree nuts, vegetables, oil seeds, and sugar and related products. U.S. agricultural trade with its North American neighbors has grown dramatically since 1994, roughly quadrupling during that time.

The increase in U.S. food exports and imports has resulted in some negative effects. For example, food production and transportation emissions have increased as a result of the extended supply chains. However, a 2008 study by researchers at Carnegie Mellon University determined that transportation-related greenhouse gas (GHG) emissions comprise a relatively small portion of agricultural supply chain emissions (about 11 percent). Food production creates the clear majority (approximately 83 percent) of GHG emissions related to the agricultural supply chain. In addition, production of different types of food creates different emission volumes. For example, the Carnegie Mellon researchers found that red meat production created 150 percent more GHG emissions than chicken or fish production.

Modes of Freight Transportation

According to a recent USDA report, "A highly competitive and efficient transportation system results in lower shipping costs, smaller marketing margins for middlemen, and more competitive export prices. Such efficiencies also result in lower food costs for U.S. consumers and higher market prices for U.S. producers."

Depending on a grocery store's location and the time of year, the various fruits and vegetables that line its shelves may come from a farm near the store's location, another U.S. region, or another country. *Source: FHWA.*

Many farms produce large volumes of agricultural products, including vegetables. More efficient freight transportation networks and improved refrigeration processes enable farms to ship their products greater distances, increasing the size of the market farms can serve. *© Shutterstock/David Litman*.

Transportation patterns for shipping agricultural goods within the United States are complex. All freight transportation modes play a role in the food supply chain, but some modes play a larger role than others. Shipments under 500 miles (804 kilometers) are almost always transported by trucks, which are a relatively fast and flexible transportation mode. Trucks are also the dominant mode for relatively time-sensitive shipments.

Rail is the second-most used mode and is more commonly employed for shipments that are more than 750 miles (1,207 kilometers) where economies of scale give the mode a comparative advantage. It is also often used for bulk product shipments, including in some cases at shorter distances.

Barges are frequently used for grain shipments produced at farms near navigable rivers, and are often cheaper than trains and trucks for transporting heavier, bulkier food products. Barge use is also common for exported agricultural shipments.

Ocean-going ships transport most non-North American exports and imports where land-based modes are not an option. In many cases, refrigerated containers or other climate-controlled equipment is necessary to enable products that are shipped internationally to remain fresh and edible through delivery to the destination market.

Pipelines are utilized to ship a limited number of liquid products that need to be transported long distances. For example, some liquid fertilizers can be shipped via pipelines.

Finally, airplanes carry a limited number of high value and/or highly perishable goods. They may be the best mode for goods that need to be delivered to the consumer market rapidly. Airplanes are often the mode of choice when there is a critical shortage of a given product that needs to be replenished quickly.

Changing Trends

Shipment patterns by mode have changed significantly over time, particularly for domestic agricultural shipments. A 2001 Iowa State University study found the truck-rail mode split for produce shipments to the Chicago, IL, market changed from 50 percent truck and 50 percent rail in 1981 to 87 percent truck and 13 percent rail in 1998. Modal split trends in more recent years for other goods have shown less dramatic but similar patterns.

According to the Transportation Services Division of USDA's Agricultural Marketing Service, domestic and export grain shipments, which include corn, wheat, soybeans, barley, and sorghum, measured by tonnage remained relatively flat for rail and barge between 2000 and 2016 but for truck shipments increased by nearly 75 percent during the same timeframe. By mode split, trucks captured 50 percent, trains carried 32 percent, and barges transported 18 percent of grain shipments in 2000. By 2016, the mode split was 61 percent trucks, 25 percent trains, and 14 percent barges.

In addition to the mode shipment disparities, product shipment disparities also exist. Between 2012 and 2016, corn, which is mostly grown for the domestic market and often produced in areas relatively close to large population centers, was transported by truck for 72 percent of shipments, by rail for 19 percent of shipments, and by barge for 9 percent of shipments. The truck, rail, and barge breakdown for wheat shipments, much of which are exported from the United States, was 29 percent truck, 54 percent rail, and 17 percent barge during the same time period, while for soybean shipments, which are often grown near major waterways, the mode shares were 51 percent truck, 22 percent rail, and 26 percent barge during the 2012 to 2016 timeframe.

The changing trends for grain shipments are likely because of multiple factors, which may include: a push by food retailers to carry smaller inventories, encouraging the use of faster, more flexible modes such as trucking; an increased focus by the railroad industry on higher value intermodal container shipments; and the growth of trade with Canada and Mexico because of the North America Free Trade Agreement. Shipments to Canda and Mexico can be handled by trucks as well as railroads. Based on continued focus on just-in-time deliveries throughout the supply chain industry—not

Percentage of Grain Shipments by Transportation Mode: 2000 Versus 2016

Year	Transportation Mode		
	Truck	Rail	Barge
2000	50	32	18
2016	61	25	14

Source: USDA.

just within the agriculture industry—the trend toward using trucks to a greater degree for agricultural shipments will likely continue at least in the near-term. That trend could have significant implications for food transportation, particularly on intercity corridors and corridors that connect to major water ports or international border crossings.

Distribution to End Markets

Like export, import, and domestic shipments, the transport methods for getting agricultural products to stores and homes via e-commerce orders are also varied and multifaceted. Food producers distribute their products to end markets in various ways. For example, for foods shipped to grocery stores, the most common method for large-scale farmers and other food producers is to rely on third-party food distribution companies. Grocery stores tend to use distributors because they can provide consistent, large-volume deliveries of many products. By buying large quantities of products, stores often receive volume-based price discounts.

Large grocery chains determine what products to store at the distributor's warehouses and where those products are stockpiled. The chains do this to improve product quality and maximize supply chain efficiency. Some very large grocery store chains remove the third-party distributors from the equation by operating as their own distributors and running their own distribution networks. Those chains establish direct relationships with large farms and agricultural producers.

Many food distributors specialize in certain types of grocery deliveries. Smaller, specialty, or regional distributors often supply dairy products and cheese, alcohol, and natural or specialty foods that are specific to a region or are highly perishable.

Though farmers and other food producers send most of their products to market via distributors, they also use other ways to sell foods, both indirectly and directly. With some products, farmers and other producers sell and deliver directly to stores, restaurants, schools, and other venues that need fresh food supplies on a regular basis. Products distributed and sold in this manner most frequently include artisanal products, baked goods, some fruits and vegetables, and some meat and seafood products. Stores sell fruits, vegetables, meats, and seafood products that they receive from both distributors and local farmers directly; the exact product supply mix depends on the time of year and the types of products.

In some cases, farmers may sell their products directly to consumers. For example, direct sales occur at farmers' markets, on-farm stores, and other community-supported merchant venues. Selling products at farmers' markets cuts out the middlemen—the distributors and grocery stores—from the equation. Farmers gain a greater net share of the sales this way and typically sell fresher products. On the negative side, selling products at farmers' markets and similar venues restricts the size of the market population with access to the goods.

Percentage of Grain Shipments by Type of Grain and Transportation Mode in 2016

Type of Grain	Transportation Mode		
	Truck	Rail	Barge
Corn	72	19	9
Wheat	29	54	17
Soybeans	51	22	26

Source: USDA, 2012–2016.

The Rise of Direct Delivery

With the growth of e-commerce, some consumers have moved away from obtaining much of their food at grocery stores. Instead, these consumers have food delivered directly to their homes and other preselected locations. Many e-commerce food delivery companies now exist, and direct shipments of produce and prepared food directly to consumers have increased in recent years. Usually these companies provide their own transportation to deliver the goods, but, in some cases, the customers pick up the prepackaged shipments themselves.

Most e-commerce food delivery companies use an on-demand third-party representative to pick up the foods at a local grocery store and deliver them directly to the customer's residence or designated delivery location. Shipments to customers may occur by car, van, bike, or on foot depending on the community's development density.

Many dairy products are hauled entirely by truck and serve a regional market area because of their perishable, time-sensitive nature. In general, more agricultural products, especially relatively high-value agricultural products, are transported by truck today compared to decades ago because of the improved roadway network and trucks' faster and more flexible operating characteristics.
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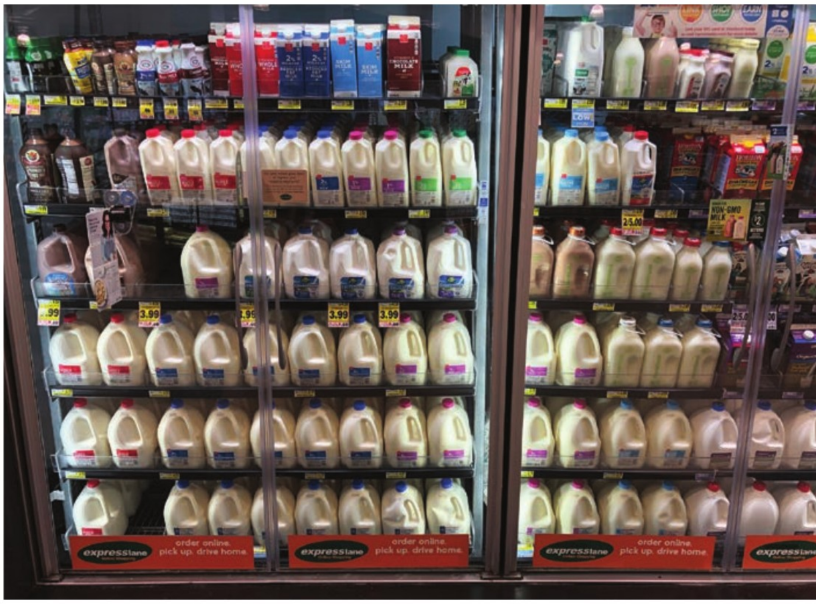


Storing goods such as milk and dairy products at appropriate temperatures both during transport and at stores is critical to maximize their shelf life and reduce product waste. *Source: FHWA.*

Another similar approach is for an employee or third-party representative to obtain customers' orders at nearby regional food warehouses (many times as leveraging "dark stores"—a term used to describe facilities that resemble conventional supermarkets except they are not open to the public and are only used to fill online orders). E-commerce food delivery companies sometimes operate the warehouses and then deliver orders to the customers' homes by car or van. In some cases, the food company employees work with the warehouse staff to assemble the shipment, while in other cases a meal kit is prepared in advance of company pickup and then delivered to customers.

A third approach for e-commerce meal deliveries is for the food delivery company to bring the customers' shipments to a local delivery depot or store and have the customers pick up their shipments there (known as "click and collect" or "in-store pickup"). This approach is less convenient for the customers in most cases, but it is easier and cheaper for the delivery companies, resulting in savings that may be passed on to the customers.

Today's farmers and other agricultural producers are also able to get their food products to customers by using e-commerce grocers that operate their own food preparation facilities. Some companies are obtaining foods directly from farms and preparing the food shipments themselves, rather than relying on grocery stores or food warehouses to gather food for their customers' orders.

For example, a former Virginia-based online grocer serving the Washington, DC, market relied on 150 suppliers to obtain a variety of locally grown, organic, and "conventional" (distributor-obtained) foods that they then sold to customers. Approximately half of the company's range of products and sales came through conventional distributors, but roughly a third of the products and sales were via local farmers and other regional agricultural producers. The grocer also had an inhouse butchery, seafood, and meal planning services to maximize the freshness and quality of its product offerings.

"The combination of the broad availability of low-cost, last-mile, and 'click-and-collect' technologies, and the multitudes of pick-pack-delivery partner options (that handle perishables) has vastly expanded and improved the optionality for food-oriented e-commerce platforms to offer their catalogues online," says Caesar Layton, founder/partner with Cultivate Ventures, the company behind the Virginia-based online grocer. "As these factors continue to improve, the number of food retailers leveraging e-commerce (regardless of size, location and offering) will continue to grow exponentially."

E-commerce food deliveries not only provide convenience benefits for customers, they also can reduce vehicles miles traveled by consolidating deliveries for multiple customers living near one another and reducing individual consumer trips to grocery stores.

The growth of e-commerce may also provide opportunities for food delivery companies to use emerging technologies such as robots, autonomous carts (for example, mini vehicles), or drones for their operations. The adoption of such technologies depends on deployment costs, technology reliability, delivery security, and the future ease or difficulty to make conventional deliveries, especially in urban areas.

Many Components, One Goal

The United States agricultural supply chain has many components—export, import, and domestic shipments; shipments by trucks, trains, ships, pipelines, and airplanes; deliveries to grocery stores, restaurants, and schools; and direct e-commerce deliveries to people's homes. All methods of food transportation need to function efficiently for the agricultural supply chain to function effectively. Fortunately, the food supply chain usually works well, and enables end consumers to obtain the foods they want, where and when they want them.

Chip Millard is a transportation specialist in the FHWA Office of Freight Management and Operations. He manages the Talking Freight webinar series and internal freight discipline activities, and researches freight economic trends. Millard holds a master's degree in geography from Indiana University of Pennsylvania and a bachelor's degree in psychology from Juniata College.

For more information, contact Chip Millard at 202-366-4415 or chip.millard@dot.gov.

FOCUS ON—CONNECTED VEHICLES

A Pathway to Secure Connections

by Jonathan Walker

USDOT is leading the way for research, design, and implementation of a security system for connected and automated vehicle networks.

Trust and protection of individual privacy, facilitated by an SCMS, are critical to ensuring successful exchange of information among vehicles and other devices. *Source: USDOT.*

Today's average smartphone wirelessly exchanges various kinds of data such as contacts, photos, videos, and location information between multiple parties using Bluetooth®, Wi-Fi, and cellular technology. For example, the Apple® iPhone® features an app called AirDrop® that enables the exchange of photo albums, events, journals, and slideshows directly to another Apple device using Bluetooth or Wi-Fi technology.

In a similar manner, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications, which are part of connected vehicle communications, enable the wireless exchange of information among vehicles, roadway infrastructure, traffic management centers, and wireless mobile devices. But, how secure is this exchange of information? A security system is critical to ensure that users of connected vehicle technology can trust in the validity of information received from other system users—even indistinct users who they do not know personally.

The U.S. Department of Transportation (USDOT) is committed to ensuring that connected and automated vehicle (CAV) technologies operate in a safe and secure manner that protects user privacy. Since 2013,

The fundamental framework of a system using digital certificates requires four key components (confidentiality, authentication, integrity, and nonrepudiation) and four structured segments (technology, implementation, policy, and standards). *Source: USDOT.*

USDOT has led the way in research and implementation of a state-of-the-art security system for CAVs that use connected vehicle communications.

Digital Certificates

Systems for connected vehicle communications use digital certificates to exchange information that all elements, including vehicles, roadway infrastructure, and traffic management centers, can validate. In cryptography, a digital certificate or public key certificate is an electronic document that proves the ownership of a digital public key—a key that the owner can share with everyone.

Each digital public key has a matching digital private key, which is known only by the owner of the digital certificate. The digital certificate in turn contains information about the identity of the owner, a unique digital signature, and the means to verify the authenticity of the digital signature using the digital public key.

Digital certificates are the basis of a fundamental framework for a system that ensures users can trust the validity of information received through connected vehicle communications. This framework requires four key components and four structured segments.

The four key components of a trusted digital certificate system are confidentiality, authentication, integrity, and nonrepudiation, or CAIN. Confidentiality means the information exchanged within the system can be kept secret. Authentication is the process of confirming the information is valid. Integrity ensures the system has not been corrupted, and nonrepudiation provides proof of data and system integrity so that an information transmitter cannot deny having sent the information.

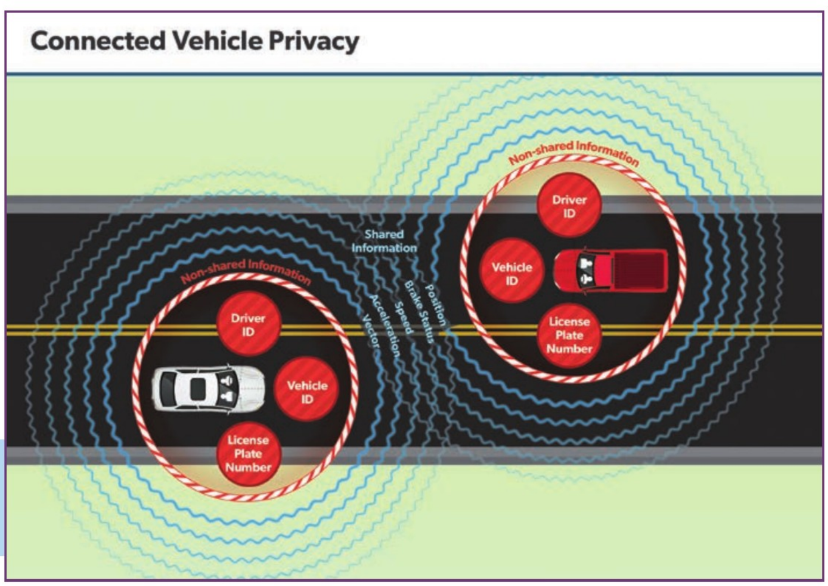
The four structured segments are technology, implementation, policy, and standards, or TIPS. Technology is the use of mathematics and algorithms to encrypt data, and implementation is the execution of the algorithms using software applications. Policy is a system of principles, procedures, or protocols that govern the outcome. Standards are widely accepted, adopted, and implemented rules and guidelines that are normally compliance processes but are not mandatory.

These four key components and four structured components are starting points for a structured framework using digital certificates that researchers and designers can build on for more complex systems.

USDOT's Proof of Concept

To test a digital certificate system in a connected vehicle environment, USDOT created the Crash Avoidance Metrics Partnership in 2014 with automotive industry and security experts to design and develop a state-of-the-art security system that enables V2V and V2I users to have confidence in one another. The partnership developed the Security Credential Management System (SCMS) proof of concept, a message security solution for connected vehicle communications that provides extensive knowledge, insight, and policies for a security system.

The SCMS proof of concept employs innovative methods of encryption and digital certificate management to facilitate trusted communication. It generates and distributes digital certificates to authenticate and validate the safety and mobility messages that form the foundation for connected vehicle technologies.



Communication between vehicles requires both security and privacy of the data exchanged. *Source: USDOT.*

The USDOT Connected Vehicle Pilot Interoperability Test successfully demonstrated interactions among different sites' onboard units and among selected onboard and roadside units. *Source: USDOT.*

The SCMS proof of concept also plays a critical function in protecting the integrity of the system by identifying and removing misbehaving devices while still maintaining privacy.

"Unlike other systems using digital certificates, the certificates from the SCMS proof of concept system contain no personal or equipment-identifying information," says Justin Anderson, a senior ITS systems engineer at Noblis. "This protects the privacy of vehicle owners while serving as system credentials so that other users in the system can trust each message."

USDOT concluded its research in December 2018 on the SCMS proof of concept and will publish several documents later in 2019, including the concept of operations, policies, and procedures.

Real-World Implementation

In addition to its proof-of-concept research, USDOT has successfully executed a real-world test of a digital certificate system as part of the Connected Vehicle Pilot Deployment Program. The program involves three locations in the United States: New York City; Tampa, FL; and Wyoming.

In September 2015 (phase 1) and September 2016 (phase 2), USDOT awarded contract agreements totaling more than $45 million to Florida's Tampa Hillsborough Expressway Authority, the New York City Department of Transportation, and the Wyoming Department of Transportation to implement a collection of connected vehicle applications using V2V and V2I communications. During phase 1, USDOT provided requirements documentation, slide presentations, and a webinar for interfacing with an SCMS. Each of the pilot sites was required to document and present a security management operating concept plan outlining the security mechanisms to protect data information flows, privacy, and security within a connected environment.

In June 2018, USDOT and the three pilot sites successfully demonstrated the exchange and validation of digital certificates using common standards during an interoperability test held at the Federal Highway Administration's Turner-Fairbank Highway Research Center in McLean, VA. USDOT and the pilot sites conducted the test to demonstrate and validate that a vehicle with an onboard device from one of the sites was able to securely receive messages from onboard units and roadside units from another pilot site, in accordance with the key connected

Connected Vehicle Pilot Deployment Program Phase I Materials

Pilot Program Websites	• USDOT Technical Events and Publications: www.its.dot.gov/pilots/technical_assistance_events.htm • New York City DOT: www.cvp.nyc • Tampa Hillsborough Expressway Authority: www.tampacvpilot.com • Wyoming DOT: https://wydotcvp.wyoroad.info
Webinars	• *Preparing an SMOC [Security Management Operating Concept Plan]* (recorded 12/9/15) • Slide presentation: www.its.dot.gov/pilots/pdf/CVP-Tech-Assistance-Webinar-Security-Operations-Concept_Final.pdf • Webinar Recording: http://itsa.adobeconnect.com/p5u9bray3le • *Preparing a Privacy Operational Concept* (recorded 2/1/2016) • Slide presentation: www.its.dot.gov/pilots/pdf/CVP_TechAssistWebinar_Privacy_v4.pdf • Webinar recording: www.its.dot.gov/exit/adobe_pilot5.htm • Privacy frequently asked questions: www.its.dot.gov/pilots/pilot_privacy_faq.htm • *SCMS Proof-of-Concept Interface Requirements* (recorded 2/10/2016) • Slide presentation: www.its.dot.gov/pilots/pdf/TechAssistWebinar_Template_SCMSIIv4.pdf • Webinar recording: www.its.dot.gov/exit/adobe_pilot9.htm
Requirements Documentation	• SCMS POC End Entity Requirements 1.2.2: https://wiki.campllc.org/display/SCP
Security Management Operating Concept (SMOC) Plans	• Final SMOC (FHWA-JPO-16-288)—Wyoming: https://rosap.ntl.bts.gov/view/dot/30810 • Final SMOC (FHWA-JPO-16-300)—New York City: https://rosap.ntl.bts.gov/view/dot/31725 • Final SMOC (FHWA-JPO-16-312)—Tampa, FL: https://rosap.ntl.bts.gov/view/dot/30827
Documents	• Security Operational Concept (FHWA-JPO-16-338): https://rosap.ntl.bts.gov/view/dot/3599

A vehicle from Tampa (white car) waits as it receives an intersection movement assist warning from a New York City vehicle (black car) during the interoperability test. *Source: USDOT.*

vehicle interfaces and standards. (For more information, see "Setting a Course to Interoperability" in the Spring 2019 issue of PUBLIC ROADS.)

"A test of this nature, involving three deployment sites and five device vendors, had never been done before," says Deborah Curtis, a highway research engineer at FHWA's Office of Operations Research and Development. The demonstration showed that digital certificates from an SCMS would enable vehicles and the roadside infrastructure to exchange information and use the information in a consistent manner, regardless of the manufacturer of the vehicle, device, or roadside equipment.

The successful implementation of digital certificates from an SCMS required extensive documentation and collaboration over a 4-year period. USDOT has assembled a collection of documents, presentations, and webinars that are available online for free. In addition, there are several webinars, slide presentations, and SCMS requirements documents for achieving a security system using connected vehicle communications in a CAV environment. These resources are available from USDOT's SCMS website at www.its.dot.gov/resources/scms.htm.

Next Steps Toward A Full-Scale SCMS

After 4 years of researching, designing, building, and implementing the SCMS proof of concept, USDOT is leading the facilitation of a full-scale SCMS as the next step to a digital certificate system in a connected vehicle communications environment. The SCMS Deployment Support Project aims to help identify and explore potential strategies for the establishment and governance of an SCMS ecosystem through engagement with stakeholders. The stakeholders range from automakers, cybersecurity organizations, digital certificate subject matter experts, roadside and onboard unit manufacturers, State governments, and telecom providers.

In fall 2018, USDOT conducted two workshops with stakeholders in McLean and San Francisco, CA, to explore potential strategies for a full-scale SCMS ecosystem. The goals were to: (1) identify one or more potential SCMS ownership and governance models, along with the next steps needed for deployment, and (2) develop a foundation for a working group/consortium to lead or assist in planning for the full-scale deployment and certificate policy development, as well as determine the role of USDOT in supporting the working group.

Workshop attendees addressed four main objectives: First, to refine understanding of stakeholder motivations, interests, concerns, and willingness to dedicate resources to deploy SCMS nationally; second, to develop ownership and governance models and the qualifying information about these models, such as steps that are needed for successful deployment to determine feasibility of the models; third, to define SCMS manager roles and responsibilities based on models favored by stakeholders; and finally, to identify and describe additional challenges, risks, and opportunities to deploying and operating a functional and sustainable full-scale SCMS.

USDOT is compiling and analyzing the results of the workshops and anticipates publishing the findings in late 2019.

"This is important work," says Ed Fok, a transportation technology specialist in FHWA's Resource Center. "An interoperable and open SCMS is essential to meet safety and mobility goals in our cooperative, automated transportation future."

Jonathan Walker, Ph.D., P.E., is the chief of policy, architecture, and knowledge transfer in USDOT's Intelligent Transportation Systems Joint Program Office, where he manages the SCMS proof of concept project. He holds a Ph.D. from Virginia Tech, an M.S. from Johns Hopkins University, and a B.S. from Howard University, all in engineering, and is a licensed professional engineer in Maryland, Virginia, and Washington, DC.

For more information, see www.its.dot.gov/resources/scms.htm or contact Jonathan Walker at 202-366-2199 or jonathan.walker@dot.gov.

Along the Road

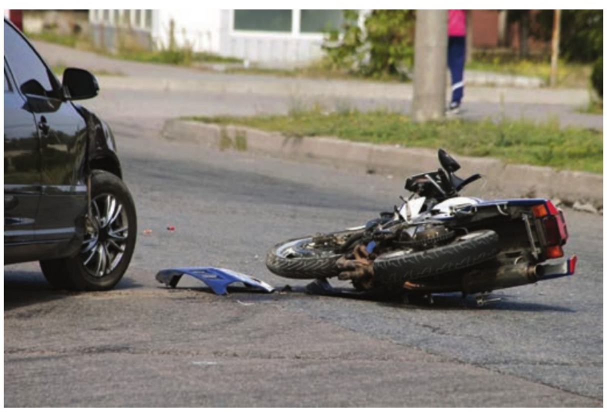
Along the Road is the place to look for information about current and upcoming activities, developments, trends, and items of general interest to the highway community. This information comes from U.S. Department of Transportation sources unless otherwise indicated. Your suggestions and input are welcome.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

Public Information and Information Exchange

Using ITS Technology to Improve Motorcycle Safety

USDOT published a report highlighting the relationship between motorcycles and intelligent transportation systems (ITS). The report, *Motorcycle Safety and Intelligent Transportation Systems Gap Analysis*, explores the potential of improving motorcycle safety through ITS.

ITS present an array of promising ways to improve motorcycle safety. While ITS technologies have predominantly targeted automobiles and commercial vehicles, little has been done to specifically address motorcycles or motorcycle safety. To help rectify this, the project surveyed a wide range of ITS technologies with potential relevance to motorcycles. It also analyzed each technology's current relevance to motorcycles and potential to improve motorcycle safety, and then further investigated those technologies with strong potential to improve motorcycle safety.



Many ITS technologies could be applied to motorcycles to improve rider safety. *© Dmitry Surov, Shutterstock.com.*

The project team conducted a comprehensive literature review and interviewed leading practitioners from a cross section of the motorcycle industry and community. The report documents a series of trends and gaps in the current state of research on motorcycle safety and ITS identified during the literature review and interviews. It also recommends strategies and areas of research to advance the overall field of ITS as it relates to motorcycle safety.

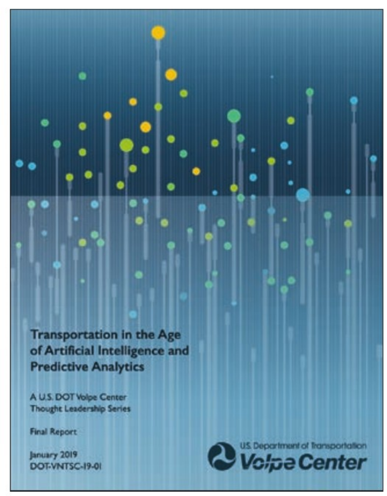
Recommended strategies include actively promoting research on motorcycle ITS and exploring synergies with closely related research; engaging the motorcycle community and general public to improve the design and acceptance of motorcycle ITS; embracing upcoming technology (particularly connected vehicles and big data applications); and collaborating with all sectors and stakeholders to promote ITS harmonization and widespread implementation.

The recommended areas of research include synergizing ITS technology and implementation with the proven technology of antilock braking systems in motorcycles; rider-motorcycle interfaces; motorcycle safety data (including preparations to take full advantage of big data moving forward); applied research and assessments of safety benefits; and the harmonization of ITS technologies and standards (such as interoperable connected vehicles).

For more information, download the report at https://rosap.ntl.bts.gov/view/dot/37089.

Applying New Technology to Transportation

USDOT's Volpe National Transportation Systems Center published a report summarizing a speaker series held from June to October 2018 that explored how new technologies may affect workers in the transportation sector. The series, titled "Transportation in the Age of Artificial Intelligence and Predictive Analytics," convened experts in government innovation, vehicle automation, and logistics to consider the promise and potential of recent breakthroughs in machine learning and data analysis.



Source: USDOT.

The experts shared their visions for how new technologies can be applied throughout the transportation sector—such as large amounts of data from mapping applications that can improve traffic modeling and save lives on U.S. roads. They also discussed how data helps freight professionals better understand complex shipping markets, and shared how the Federal government can encourage transportation innovation without being overly prescriptive.

The interactive online report includes video highlights from each speaker, as well as articles summarizing each presentation.

For more information, the report is available at www.volpe.dot.gov/sites/volpe.dot.gov/files/docs/events/63256/transportationaifinalreport.pdf.

Volpe Center

GeoTechTools Website Now Supports Mobile Devices

In April 2019, Iowa State University updated its GeoTechTools website to support the use of tablets and mobile phones. The GeoTechTools website provides a system for the dissemination of research results developed for the second Strategic Highway Research Program (SHRP2) project R02: *Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction, and Stabilization of the Pavement Working Platform*.

The updated platform retains all of the technical content of GeoTechTools. It adds increased functionality such as search capabilities and dynamic dimensioning for ease of use and improved accessibility on various devices including desktops, laptops, tablets, and phones. All of the content that had been in PDFs has been integrated into the new platform as HTML, making it easier to reference and browse—especially on mobile devices because downloads are no longer necessary. Additionally, the updated platform incorporates more security measures.

The developers welcome comments and suggestions on the new platform.

For more information, visit https://geotechtools.geoinstitute.org/.

Iowa State University

PBIC Launches New Website With Data Resource Tool

The Pedestrian and Bicycle Information Center (PBIC) recently launched a redesign of the PedBikeInfo website to connect practitioners and others with tools that help advance pedestrian and bicyclist safety, mobility, access, equity, and more. The website is available at www.PedBikeInfo.org.

Source: PBIC.

The new site builds on content and resources restructured into new areas for improved functionality, based on input from a variety of website users and stakeholders. A section for facts and figures provides updated data related to pedestrian and bicyclist concepts, and PBIC added 30 new topic pages with resources related to key issues. The site also includes a searchable archive of webinars, resources, and best practices developed by experts across a variety of fields.

The redesigned website links to PedBikeData, a new clearinghouse of pedestrian and bicycle datasets for researchers and practitioners. Funded and developed by the Collaborative Sciences Center for Road Safety (CSCRS), PedBikeData provides collision, count, and infrastructure data from sources across the United States to download. The database contains more than 3,000 records, most of which are readily available online. CSCRS welcomes others to partner on future phases of the site to improve it as a resource for all who are interested in pedestrian and bicyclist safety.

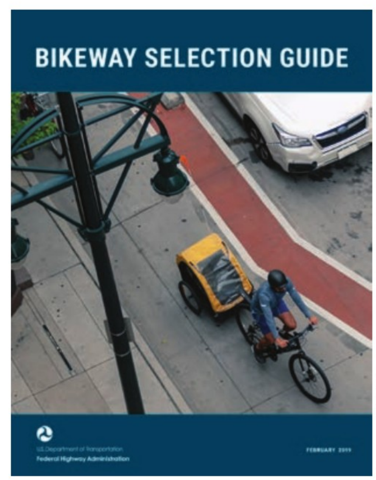
For more information, visit www.PedBikeInfo.org and www.PedBikeData.org.

PBIC

FHWA Publishes Guidance For Selecting Bicycle Facilities

In February 2019, FHWA released the *Bikeway Selection Guide* (FHWA-SA-18-077) to help transportation practitioners consider and make informed decisions about various bikeway types. The guide outlines a process for identifying the desired bikeway type and assessing and refining potential options based on real-world conditions and decisionmaking factors.

The report highlights linkages between the bikeway selection process and the transportation planning process. It draws on research where available and emphasizes engineering judgment, design flexibility, documentation, and experimentation. The report may be downloaded at https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf.



Source: FHWA.

In developing the *Bikeway Selection Guide*, researchers conducted a comprehensive literature review to identify and evaluate existing guidance for separating bicyclists from traffic, identify common bikeways for separating bicyclists from traffic, summarize the relative safety impact on bicyclists for these bikeways, and identify and evaluate decisionmaking strategies for selecting a bikeway.

FHWA published the summary of the results, *Literature Review: Resource Guide for Separating Bicyclists from Traffic* (FHWA-SA-18-030). The document discusses the history of guidance for separating bicyclists from traffic in the United States to provide context for current bicycling activity and safety. The literature identifies example practices and metrics for selecting an appropriate bikeway treatment to accommodate bicyclists on public roadways. The literature review is available at https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18030.pdf.

NATIONAL HIGHWAY INSTITUTE

Training Update

by Marisa Beck

Helping Transportation Agencies Adopt TPM

Transportation performance management (TPM) is a strategic, data-driven approach for ensuring safe and reliable travel. TPM uses system information to make investment and policy decisions to achieve performance goals. By using TPM principles, transportation agencies can select and implement projects that produce desired performance outcomes.

To help agencies understand and adopt TPM strategies, the Federal Highway Administration's Office of Stewardship, Oversight, and Management continues to expand its TPM training courses offered through the National Highway Institute (NHI). NHI offers in-person, instructor-led TPM courses throughout the country, as well as web-based training that participants may take online at their own pace.

New TPM Courses

Transportation Performance Management for Safety—Essentials (course 138006A). NHI developed this 1-day instructor-led training by condensing a 2-day version (course 138006) in August 2018. The course is offered at no cost to metropolitan planning organizations and State departments of transportation. It explains the safety performance measures and noteworthy practices necessary for States to comply with requirements of the Moving Ahead for Progress in the 21st Century Act (MAP-21) and Fixing America's Surface Transportation (FAST) Act. The course offers an evidence-based and data-driven methodology for setting safety targets and provides participants with an understanding of the safety data needed to meet TPM requirements. The course includes hands-on exercises for reviewing crash data trends and establishing safety targets based on planned safety programs, external factors, and countermeasure deployment.

Transportation Performance Management for Congestion Including Freight (course 138010). This blended web-based and web conference course, launched in March 2019, has two components: 6 hours of individual web-based training and 1 hour of live web conference instruction. Sessions are offered on demand in 2-week periods, with the web conference portion held toward the end of the session. Participants complete the web-based training prior to attending the conference session, during which instructors go over the training exercises and answer questions. This training is offered free of charge. The goal is to provide the target audience with the skills and abilities to compile and analyze highway system performance data, calculate performance measures and establish targets, report highway system performance, and assess progress toward achieving performance targets.

Getting Started on Effective TPM for Pavements (course 138014). This 1-hour web-based training, launched in February 2019, provides an effective, time-efficient, and accessible format for practitioners in State departments of transportation, metropolitan planning organizations, FHWA, and other agencies. The course is free of charge and uses knowledge checks and other interactive features to engage participants. The goal of the training is to provide a foundational knowledge of new legislation and regulatory requirements related to pavement condition performance to give participants the tools and skills needed to help their agencies meet the new requirements.

Getting Started on Effective TPM for Bridges (course 138015). This 1-hour web-based training, also launched in February 2019, gives learners an introduction to the new legislation and regulatory requirements related to bridge condition performance and the actions needed to meet these requirements. The no-cost training gives participants the working knowledge needed to comply with regulation requirements, including data needs, metric calculations, reporting, target setting, collaboration with partners, and making significant progress relative to their State's identified performance needs.

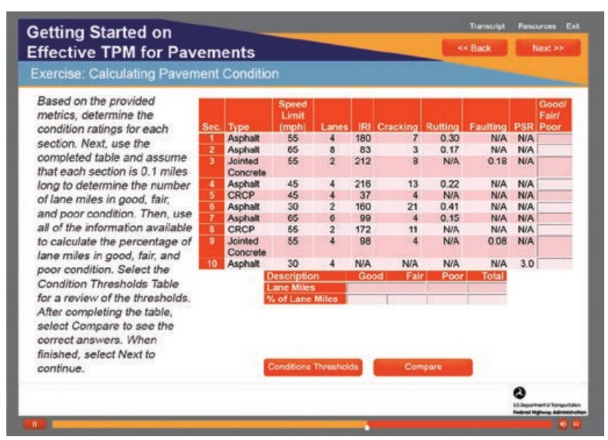
Upcoming Courses

In addition to the above offerings, the Office of Stewardship, Oversight, and Management is developing additional web-based TPM trainings expected to launch in late 2019. These courses will include topics covering planning, introduction to the Highway Performance Monitoring System (HPMS), data for TPM, onroad mobile source emissions, freight, monitoring and adjusting transportation performance, communicating and reporting on TPM, and investment decisionmaking.

Plans are also in the works for 18 training videos, which will be hosted on FHWA's YouTube channel.

For more information on currently available courses, or to sign up for email updates on TPM courses, visit www.nhi.fhwa.dot.gov. To register for a course, visit the individual course description page.

Marisa Beck is a contracted marketing analyst for NHI.



Web-based training courses engage participants through interactive features including knowledge checks and hands-on exercises. *Source: NHI.*

Communication Product Updates

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

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

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

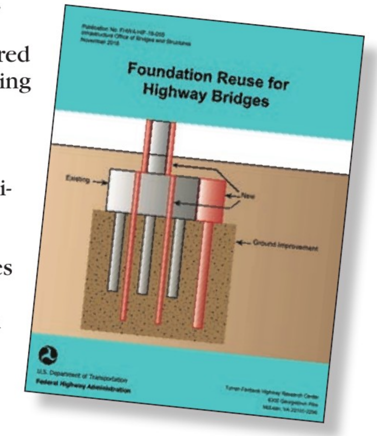
R&T Product Distribution Center
Szanca Solutions/FHWA PDC
700 North 3rd Avenue
Altoona, PA 16601
Telephone: 814–239–1160
Fax: 814–239–2156
Email: report.center@dot.gov

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).

Foundation Reuse for Highway Bridges (Report)
Publication Number: FHWA-HIF-18-055

When an existing bridge is being considered for reconstruction or major rehabilitation because of a deteriorated or obsolete superstructure, the foundation may still have significant functional value. Reusing these foundations during bridge replacement or widening can provide significant cost and time savings over constructing new elements. The potential time savings can reduce mobility impacts, and the cost savings can increase the economic viability and sustainability of the project.

FHWA's report *Foundation Reuse for Highway Bridges* focuses on reusing bridge foundations for bridge reconstruction projects. The report addresses critical issues encountered during the decisionmaking process, including the assessment of existing bridge foundations for structural and geotechnical integrity, durability, and load-carrying capacity. It also discusses planning for reuse during the construction of new bridges, including strengthening and designing bridge foundations for future reuse—an important sustainability initiative.



The report includes examples from the United States and Canada to highlight the benefits of foundation reuse from social, environmental, and economic perspectives. The report is geared toward transportation professionals and agencies interested in reusing bridge foundations.

The document is available for download at www.fhwa.dot.gov/publications/research/infrastructure/structures/18055/hif18055.pdf.

Using Data Analytics for Cost-Effective Prediction of Road Conditions: Case of the Pavement Condition Index
Publication Number: FHWA-HRT-18-065

Municipalities and transportation departments devote considerable effort to collecting data, particularly related to road conditions. Many small municipalities do not have sufficient resources to collect data regularly, and in larger municipalities, collecting field-based data may be hampered by crew safety and traffic interruptions. Data analytics could help reduce these negative impacts. In this study, researchers used data analytics to test if affordable and easy-to-collect data can be used to predict future values of the Pavement Condition Index (PCI).

This paper demonstrates how machine-learning models can help municipalities predict the PCI values of roads using easy-to-collect and cost-effective attributes. The scope of this paper is not limited to predicting the conditions of roads using data analytics. The authors also investigated the relative significance of a road's attributes in its deterioration. This type of analysis can guide

municipalities and transportation departments in crafting a more efficient policy of data collection and data management. Researchers chose to use the PCI because municipalities and transportation departments in North America commonly use it.

The document is available for download at www.fhwa.dot.gov/publications/research/infrastructure/pavements/ltpp/18065/index.cfm.

The Role of Artificial Intelligence and Machine Learning in Federally Supported Surface Transportation Initiatives
Publication Number: FHWA-HRT-18-066

The term artificial intelligence might call to mind talking robots that efficiently perform some of the functions that humans do, or—within the context of the transportation sector—cars driving by themselves. However, artificial intelligence is currently helping highway transportation researchers answer many questions that will result in safer and more reliable roadways.

The Role of Artificial Intelligence and Machine Learning in Federally Supported Surface Transportation Initiatives, published by FHWA's Exploratory Advanced Research (EAR) Program, explores the development of artificial intelligence and machine learning technology within the surface transportation sector. FHWA seeks to make surface transportation safer and more efficient by collaborating with universities, industry, and other Government agencies that conduct cutting-edge research in artificial intelligence.

The publication examines how artificial intelligence in the transportation sector can benefit the public, and how the EAR Program supports research in artificial intelligence and machine learning. It also addresses challenges and opportunities associated with this new and promising technology.

The document is available for download at www.fhwa.dot.gov/publications/research/ear/18066/18066.pdf.

Applications of Knowledge Discovery in Massive Transportation Data: The Development of a Transportation Research Informatics Platform (TRIP)
Publication Number: FHWA-HRT-19-008

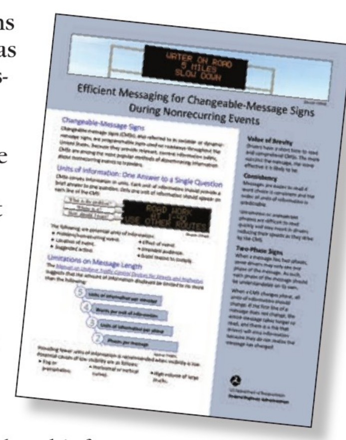
Transportation researchers and practitioners have access to enormous amounts of data but often lack the tools to easily store, manipulate, and analyze these data. The Transportation Research Informatics Platform (TRIP) is an informatics-based system designed to manage large amounts of transportation data and provide researchers an efficient way to conduct analytics on big data.

The objectives of TRIP include creating the ability to handle large quantities of transportation data; using open-source technologies and tools to ingest, store, align, and process data; accepting structured, semistructured, and unstructured datasets from any source; providing an efficient way to query data without indepth knowledge of metadata; integrating open-source and consumer off-the-shelf analytics products; and providing visualization tools to offer greater insights into data. TRIP architecture is flexible and built on state-of-the-art, open-source technology developed with big data in mind. Although predominantly developed for transportation safety research, TRIP can address issues pertaining to operations and maintenance given the incorporation of the appropriate datasets.

This report supplies the resources and instructions on how to set up an instance of the platform and how to operate it, and will be useful for transportation researchers, operators, and data managers interested in working with large transportation datasets.

The document is available for download at www.fhwa.dot.gov/publications/research/safety/19008/19008.pdf.

Efficient Messaging for Changeable-Message Signs During Nonrecurring Events
Publication Number: FHWA-HRT-19-012



Changeable-message signs (CMSs), also referred to as variable- or dynamic-message signs, are programmable signs used on roadways throughout the United States. CMSs provide relevant, current information safely, and are among the most popular methods of disseminating information about nonrecurring events to travelers.

This publication examines the various aspects of creating useful and informative CMSs. Topics discussed in the document include units of information, limitations on message length, message brevity and consistency, and phrases to avoid.

The document is available for download at www.fhwa.dot.gov/publications/research/safety/19012/19012.pdf.

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U.S. Department of Transportation

Federal Highway Administration

Collaborate with CARMA

FHWA's software platform is facilitating a transportation transformation through automated vehicles.

These CARMA3 vehicles are equipped with the CARMA platform, which enables communication between vehicles and roadway infrastructure. *Source: FHWA.*

The Cooperative Automation Research Mobility Applications (CARMA) platform equips vehicles with the ability to interact and cooperate with roadway infrastructure and other vehicles—ultimately improving efficiency and safety and transforming transportation systems management and operations.

CARMA is an open source software platform that runs on a computer installed in a vehicle. The computer interacts with the vehicle's devices to enable cooperative automated vehicle maneuvers.

Join the Collaborative

The CARMA Collaborative is a growing community of CARMA users invested in developing intelligent transportation solutions. Please share this information with your professional associates.

FHWA created the platform to be vehicle and technology agnostic, enabling a wide range of participants in the transportation industry to test it on their own vehicles. CARMA's innovative approach and design encourages collaboration with industry, academia, and other public agencies on cooperative automation applications.

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

U.S. Department of Transportation
Federal Highway Administration

It's All About ROUNDABOUTS

National Roundabouts Week— September 16–20, 2019

FHWA

Each year, FHWA celebrates National Roundabouts Week during the third week in September. Modern roundabouts reduce severe crashes by approximately 80 percent compared to traditional two-way stop-controlled intersections.

Agencies can implement roundabouts in both urban and rural areas and under a wide range of traffic conditions. Today, there are more than 4,000 modern roundabouts in the United States.

FHWA encourages transportation agencies to consider roundabouts during new construction and reconstruction projects, as well as for existing intersections that have been identified as needing safety or operational improvements. There's no way around it—roundabouts are an effective safety countermeasure.

Get Involved:

- Visit FHWA's National Roundabouts Week website at https://safety.fhwa.dot.gov/nrw for more information, tips, and facts.
- Join the dialogue on social media with #RoundaboutsWeek.

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