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Public Roads

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

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Front Cover—Detroit's QLINE electric streetcar, launched in 2017, is the outcome of an unprecedented public-private partnership providing a model for regional collaboration. The project is an example of the innovative technologies, methods, and processes encouraged by FHWA to improve the Nation's transportation system. FHWA is also exploring innovations like drones and alternative contracting methods. *Photo: Michigan DOT Photography Unit.*

Back Cover—Alternative fuel vehicles are growing in numbers—but continued growth depends on adequate charging and fueling infrastructure. FHWA is supporting proposals to designate alternative fueling corridors across the highway system. The South Carolina Department of Transportation, with support from the Palmetto Clean Fuels Coalition, was one of the first to install signs along alternative fuel corridors in 2017. For more information, see "Refueling America" on page 10 in this issue of PUBLIC ROADS. *Photo: South Carolina Energy Office.*

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Guest Editorial

Weather-Savvy Roads Can Save Lives

Heavy rain, snowstorms, dense fog, and other adverse weather conditions can have significant impacts on the safety and mobility of road users. Over the past decade, nearly a quarter of all vehicle crashes occurred under adverse weather conditions, translating into almost 6,000 deaths and 450,000 injuries each year. Likewise, the delays associated with adverse road weather can have profound and lasting economic impacts.

To mitigate these impacts, the Federal Highway Administration's Road Weather Management Program has been promoting the Weather-Savvy Roads initiative through the fourth round of FHWA's Every Day Counts program. The Weather-Savvy Roads initiative enables transportation and public works agencies to be more proactive in managing their transportation systems before and during weather events.

Specifically, Weather-Savvy Roads focuses on two measures. The first, Pathfinder, supports increased collaboration among State departments of transportation, the National Weather Service, and weather service contractors in order to translate anticipated road conditions and weather forecasts into clear, concise, consistent, impact-based messages for the traveling public. The second solution, Integrating Mobile Observations, promotes the collection of mobile weather, road, and vehicle data from agency fleets to improve situational awareness of road conditions and feed into forecasts regarding weather that could affect roads.

The timing of weather events, along with traffic levels and road conditions, can magnify significantly the impact of adverse weather. Effective collaboration and data collection are not just helpful, but also are essential to effective management of traffic, road maintenance, and assets. They also are critical to manage and measure system performance. For example, when surveyed, nearly all Utah travelers had received Pathfinder-based information about a weather event, with the majority changing their travel plans as a direct response. In Michigan, the DOT used 25 percent less salt as a direct result

of implementing Integrating Mobile Observations, leading to an annual cost savings of $2.1 million.

Simply put, a more complete picture of real-time and forecasted conditions and associated impacts across a transportation network facilitates improved decisions on road weather management by decision makers, operators, maintenance crews, and the public. Pathfinder and Integrating Mobile Observations deliver easily implementable solutions that provide significant safety and mobility benefits, along with substantial cost savings for agencies.

As evidence of interest in this topic, over half of all States recognized the value of the Weather-Savvy Roads initiative and selected it for accelerated deployment during this Every Day Counts cycle. FHWA is pulling together various resources and technical guidance documents to help agencies move forward with implementing the Pathfinder and Integrating Mobile Observations solutions as part of their Every Day Counts programs.

For agencies interested in learning more and becoming active in Weather-Savvy Roads deployments, please check out https://collaboration.fhwa.dot.gov/dot/fhwa/RWMX/SiteAssets/home.aspx or contact Paul Pisano at paul.pisano@dot.gov.

Doing so could save lives on your State's highways!

Paul Pisano
Team Leader, Road Weather and Work Zone Management
Office of Transportation Operations
Federal Highway Administration

HOT TOPIC

by Tiffany Julien

Surveying Freight Transport Around the World

The B4 Freight Technical Committee of the World Road Association examines issues involving cargo transport. The committee's B4.1 working group investigates national policies for freight transport and logistics. Since its kickoff in 2016, the working group has focused on researching multimodal freight transport policies in developing countries, countries in transition, and developed countries. In many nations, policies for freight transport are neglected or undervalued. Well-functioning freight transport systems are crucial for prosperous economies and thriving societies.

To improve understanding of multimodal freight policies, the working group developed a survey to look for national case studies, best practices, and lessons learned. Sixteen countries responded: Argentina, Australia, Austria, Bolivia, Canada, Czech Republic, Finland, Italy, Japan, Norway, Peru, South Africa, Sweden, Switzerland, United Arab Emirates, and the United States of America. Belgium also committed to completing the questionnaire.

Each respondent provided a detailed explanation of the modal split in its country, the governing structure of its national freight policy, successful best practices, and information about challenges and opportunities. Two responses are discussed here.

U.S. FAST Act

The Fixing America's Surface Transportation (FAST) Act of 2015 specifies goals for improving the performance of the National Multimodal Freight Network to ensure that it provides a foundation for competing in the global economy. Specifically, the FAST Act establishes a National Multimodal Freight Policy with goals to guide decision making and requires the development of a strategic plan to implement the goals.

The FAST Act also creates a discretionary freight-focused grant program that will invest $4.5 billion over 5 years. States, metropolitan planning organizations, local and tribal governments, special purpose districts, and public authorities (including port authorities) can apply for funding to complete projects that improve safety and help to eliminate freight bottlenecks. The legislation also establishes a National Highway Freight Program with $6.3 billion in formula funds over 5 years for States to invest in freight projects. Up to 10 percent of the funds can be used for intermodal projects.

Creating a freight transportation funding mechanism is a best practice that other countries could replicate. Tracking spending on freight networks could provide a process for prioritizing projects and could be critical to economic stability.

Switzerland HVC

In 2001, Switzerland introduced a heavy vehicles charge (HVC) that all transport companies have to pay on all public roads. The tariffing is based on maximum gross weight, kilometers driven, and emissions category,

As part of its focus on national policies for freight and logistics, the World Road Association's working group on freight visited this Mexico City facility in March 2017.

replacing a previous flat rate for trucks. An electronic collection system makes it possible to charge without interrupting the flow of traffic. The revenues are used mainly for new rail infrastructure and improving existing road and rail infrastructure.

The system's impacts and benefits include an increase in the average size of truck loads and reduction of the number of truck trips, including empty trips; decreased truck mileage by 20 percent; reduced freight traffic on transalpine roads; and an increased number of environmentally friendly vehicles in the fleet. The requirements resulted in no significant shift to vans or minor roads and only a limited increase in inflation and a limited detour of traffic to Austria and France.

These successes resulted from effective preparation for implementation; the HVC's simplicity, reliability, and cost efficiency; uniform implementation on all public roads; sound calculation of the charges; costs based on maximum permitted weight and not load (an incentive to increase loads and reduce empty trips); and public acceptance.

Future Final Report

These two examples and other information gleaned from the survey will support the development of a final report for the 2019 World Road Congress. The report will focus on trends and challenges impacting multimodal freight transportation, the drivers behind national multimodal freight policies, a summary of key survey findings, and options for future research. The report also will highlight best practices from the survey that domestic audiences, such as State partners in the United States, can replicate.

This sharing of information provides valuable first-hand insights not readily available by other means. According to Hinko van Geelen of Belgium, co-leader of the working group, "The group's research is important because it is about sharing experiences and finding common ways to improve multimodal freight policies."

Tiffany Julien is leader of the working group and a transportation specialist at the Federal Highway Administration's Office of Freight Management and Operations.

INNOVATION CORNER

by Tony Furst

Streamlining Tribal Assistance

Building and maintaining the Nation's roadways is a massive undertaking, especially for local and tribal agencies juggling increasingly complex challenges with limited funds. In 1982, Congress recognized the need for assistance and created the Local Technical Assistance Program in the Federal Highway Administration, followed 9 years later by legislation establishing the Tribal Technical Assistance Program (TTAP). For more than 25 years, TTAP has delivered training and technical assistance to help the Nation's tribes build their transportation workforce capacity and address road network challenges.

Today, technology enables forms of communication, training, and collaboration undreamed of a quarter century ago. Innovation advancements—from the Internet and smartphones to the integration of computer technology in vehicles—are generating new approaches to operating the tribal road network, which includes 58,500 miles (94,000 kilometers) of public roads owned by tribes and the Bureau of Indian Affairs, 102,500 miles (165,000 kilometers) of State and local roads, and 930 bridges.

"Advancements have profoundly changed our ability to deliver training and education and use innovation to manage transportation networks," says Victoria J. Peters, director of FHWA's Center for Local Aid Support, which oversees TTAP. "It's time to consider new options to best meet the needs of tribes in training and technical assistance."

In January 2018, FHWA launched a 2-year pilot to operate one TTAP Center, a change from the seven regional TTAP centers that served tribes in the past. In addition to reducing redundancies, one center enables TTAP to provide a greater level of expertise on issues that challenge tribes in managing their road networks, deliver consistent skills-oriented training and materials, and offer expanded access to training opportunities.

"Through this pilot, we're working with the tribes to meet their needs and explore ways to enable the program to go from good to great," says Peters. "It's about finding efficiencies, being more effective in how we train and provide technical assistance, accommodating regional differences, and improving a program that offers essential services to tribes."

Virtual Centers of Excellence

A key feature of the TTAP Center is five virtual Centers of Excellence that provide expertise, best practices, and training in highway asset and data management, planning and program management, project delivery, safety, and operations and maintenance. Each Center of Excellence is staffed by experts who deliver training and technical assistance in their focus areas to tribes across the country.

"If you have a safety challenge, you can work with a safety expert. If you have a maintenance question, a maintenance expert will assist you," says Peters. "Our experts have access to the resources of FHWA and other organizations to ensure you get the most current information to resolve your questions."

Pueblo of Acoma

The TTAP Center's updated delivery model offers greater access to training and expertise for tribal agencies managing roads such as this one in the Pueblo of Acoma in New Mexico.

The virtual Centers of Excellence offer a core training curriculum in each focus area on basic through advanced topics to build a strong tribal network of roadway knowledge. The centers will offer more hours of training than ever before and expanded training options, including face-to-face classes across the country and computer-based e-learning.

Assisting tribes with implementing innovations is a priority of the TTAP Center. "New technologies and practices are key to managing road networks effectively and efficiently, so we're looking for ways to incorporate innovations into the curriculum and share that expertise with tribes," says Peters.

Tribal Roads Scholar Certification

The TTAP Center also is developing a national Tribal Roads Scholar certification program geared to maintenance workers, equipment operators, and road managers. The program will provide comprehensive skill development on essential maintenance, operations, and safety topics and two levels of certification.

The center offers easy-to-use information sources, including a Web site that serves as a one-stop shop to access training information, find resources, and learn about best practices. A quarterly newsletter will feature program updates, details on upcoming events, and success stories. The center is producing tribal case studies and a toolkit of guidance documents, sample policies and templates, and standard specifications and plans.

"The TTAP Center is the new point of contact for tribes' training and technical assistance needs," Peters says, "with a cadre of experts and resources available at your fingertips."

For more information, visit www.fhwa.dot.gov/innovativeprograms/centers/local_aid/ttap.

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

Building Connections That Last

by Mark Leonard

Ultra-high performance concrete, like that being poured by these workers on I–81 to connect bridge deck panels, can improve the quality and durability of connections between precast bridge elements.

FHWA is encouraging the use of ultra-high performance concrete to join prefabricated bridge elements and improve their performance.

The Federal Highway Administration, during the first two rounds of its Every Day Counts (EDC) initiative, EDC-1 and EDC-2, promoted prefabricated bridge elements and systems to help improve quality and durability and shorten onsite construction time. Prefabricated bridge elements, however, need to be connected onsite, and the overall benefit of using prefabricated bridge elements is limited by the quality and durability of those connections.

To address this issue, FHWA is promoting ultra-high performance

concrete (UHPC) in EDC-3 and EDC-4 to improve the strength, simplicity, and durability of prefabricated bridge element connections. This innovation builds on the experiences of early adopters, starting in 2009 and continuing today with implementation by dozens of States across the country.

"Ultra-high performance concrete is an advanced construction material that offers performance that far exceeds expectations for conventional concretes and grouts," says Ben Graybeal, FHWA's team leader for bridge engineering research in the Office of Infrastructure Research and Development. "Although UHPC can be expensive, targeted use to grasp specific opportunities has proven to be highly valuable to bridge owners. In the U.S. bridge market, using UHPC to cast simpler, more durable connections between prefabricated bridge elements is the 'killer app' that has emerged as the entry point for owners, consultants, and contractors to begin using this new class of concrete."

What Is UHPC?

UHPC is a fiber-reinforced concrete with mechanical properties that exceed those of conventional concrete.

The common ingredients of UHPC include portland cement, supplemental cementitious materials such as silica fume and fly ash, fine aggregate, superplasticizer, steel fibers, and water. These ingredients are used to varying degrees in conventional concrete. What greatly differentiates UHPC from conventional concrete, however, is the amount of cementitious material, the type of aggregate, and the fiber content. According to FHWA's *Ultra-High Performance Concrete: A State-of-the-Art Report for the Bridge Community* (FHWA-HRT-13-060), UHPC can have 2.5 times more cementitious material than conventional field-cast concrete.

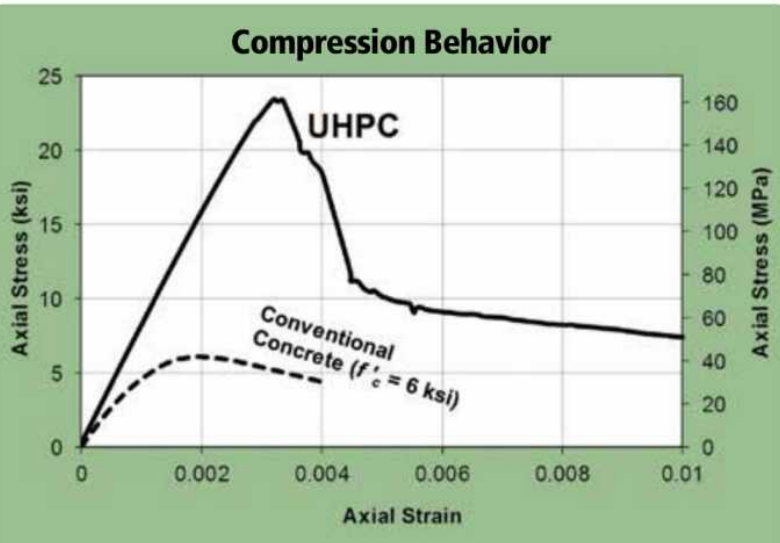
Most commonly, only fine aggregates such as sand and glass powder are used in UHPC, creating a gradation that, when combined with the cement, provides a dense matrix with a discontinuous pore structure that prevents moisture from penetrating the concrete and significantly reduces permeability compared to conventional concrete. Steel fibers are not commonly used in bridge concretes, but UHPC often has steel fibers amounting to 2 percent by volume. At 2 percent, the amount of steel fiber in UHPC is comparable to the amount of reinforcing steel bars often used in conventional field-cast bridge concrete.

Shown are the dry ingredients for a UHPC mix: steel fibers (left) and aggregate with cementitious material (right).

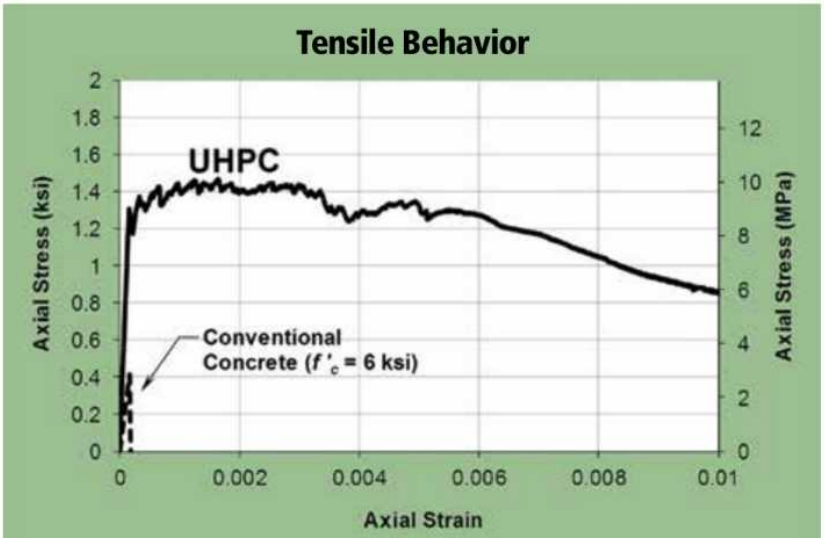
FHWA defines UHPC as having a water-to-cementitious ratio less than 0.25, a compressive strength greater than 21.7 kips per square inch, ksi (150 megapascals, MPa), and sustained post-cracking tensile strength greater than 0.72 ksi (5 MPa). At 21.7 ksi (150 MPa), UHPC is more than four times stronger in compression than most conventional field-cast concretes. More important, the tensile strength of UHPC is higher than conventional concrete, and UHPC retains its tensile strength after cracking. The direct tension cracking strength of steel fiber reinforced UHPC can be as high as 1.2 ksi (8.5 MPa), or more than three times the tensile strength of most conventional field-cast concretes. Thus, compared to conventional concrete, UHPC can make stronger connections between prefabricated bridge elements. For more information, see *Ultra-High Performance Concrete: A State-of-the-Art Report for the Bridge Community* and *Design and Construction of Field-Cast UHPC Connections* (FHWA-HRT-14-084).

Advantages of Using UHPC

Highway agencies use prefabricated bridge elements to help improve the quality and durability of bridges and to accelerate onsite construction. The offsite fabrication of bridge elements allows for careful use of high-quality materials in a



UHPC can be more than four times stronger in compression than conventional concrete, as shown in this graph of results from test specimens of UHPC and conventional concrete. *Source: FHWA.*



Here, the graph shows the dramatic difference between the behavior of test specimens of UHPC and conventional concrete under tension. *Source: FHWA.*

controlled environment. These superior bridge elements, however, are only as good as their connections.

Connecting prefabricated bridge elements typically requires splicing reinforcing steel bars within the connection, and the bars carry the tension forces from one element to the other. Long splice lengths and hooks in the reinforcing steel bars are used to help transfer the forces through conventional concrete.

However, the strength and bonding characteristics of UHPC enable designers to eliminate the hooks and make the splice lengths shorter, with the concrete taking a greater and more efficient role in transferring the forces through the connection. In other words, with UHPC the connections can be smaller, and the reinforcing steel details can be simpler.

Connections made with conventional concrete can deteriorate because of water and chloride infiltration, which eventually causes freeze-thaw damage to the concrete and corrosion of the reinforcing steel. In contrast, UHPC samples exposed to marine conditions at Treat Island, ME, were in excellent condition after 15 years, despite undergoing approximately 100 freeze-thaw cycles per year. The chloride penetration in the samples was one-third that of typical high-performance concrete. For more information, see "Marine Performance of UHPC at Treat Island" in *Ultra-High Performance Concrete and Nanotechnology in Construction* at www.uni-kassel.de/upress/online/frei/978-3-86219-264-9.volltext.frei.pdf. According to *A State-of-the-Art Report for the Bridge Community*, the dense matrix of UHPC stops water from penetrating into the concrete, which prevents the freeze-thaw damage and steel corrosion that can cause conventional concrete to deteriorate.

In short, the benefits of using UHPC for connections are improved strength, simplicity, and durability. The material cost of UHPC can be high, but the cost benefits in terms of the connection details, field assembly, and long-term performance are significant.

Comparison of what a precast deck panel connection made with conventional concrete (left) might look like compared to one made with UHPC (right).

Offsetting UHPC's Higher Cost

The high cement content, tight gradation control of the ingredients, and steel fibers make UHPC significantly more expensive than conventional concrete. Although many highway agencies understand the strength and durability advantages of UHPC over conventional concrete, the higher material costs have so far discouraged transportation agencies from routinely using UHPC to replace the conventional concrete used in bridges.

With connections between bridge elements, however, the situation is different. The need for strength and durability is pronounced, and the relative quantities of UHPC needed for connections are small. This is why the FHWA EDC initiative has focused on UHPC connections. Also, smaller connections with less concrete and reinforcing steel are used with UHPC. This helps to offset the higher material costs. When transportation agencies consider life-cycle costs, the durability of UHPC further offsets initial costs by reducing the need for future repairs.

The 3.5-mile (5.6-kilometer)-long Pulaski Skyway illustrates these life-cycle cost considerations. The skyway carries U.S. 1 and U.S. 9

Locations of U.S. Bridges with UHPC Connections

The map shows the locations of more than 100 bridge projects in the United States that have used UHPC. The various colors of the dots indicate the year that the bridge employed UHPC, starting with 2006 and continuing through 2017. *Source: FHWA.*

between Newark, NJ, and Route 139, which connects to the Holland Tunnel into New York City. The New Jersey Department of Transportation currently is replacing the deck on the skyway using precast deck panels attached with UHPC connections. In addition to decreasing the cost of future repairs, the use of UHPC connections reduces the high costs of traffic control and the costs to users when lanes are closed for repairs. For more information on the Pulaski Skyway project and the use of UHPC, see the webinar recording at www.fhwa.dot.gov/innovation/everydaycounts/edc_4/uhpc_webinar_recording.cfm.

In summary, the cost of using UHPC for bridges is reduced by using it only for connections, and by using it to decrease the size and increase the durability of the connections.

Highway Agency Use of UHPC

The first highway project in the United States that employed UHPC was the Mars Hill Bridge in Wapello County, IA, constructed in 2005 (completed in 2006). The Iowa Department of Transportation and its partners on the project used UHPC to make the bridge's concrete girders.

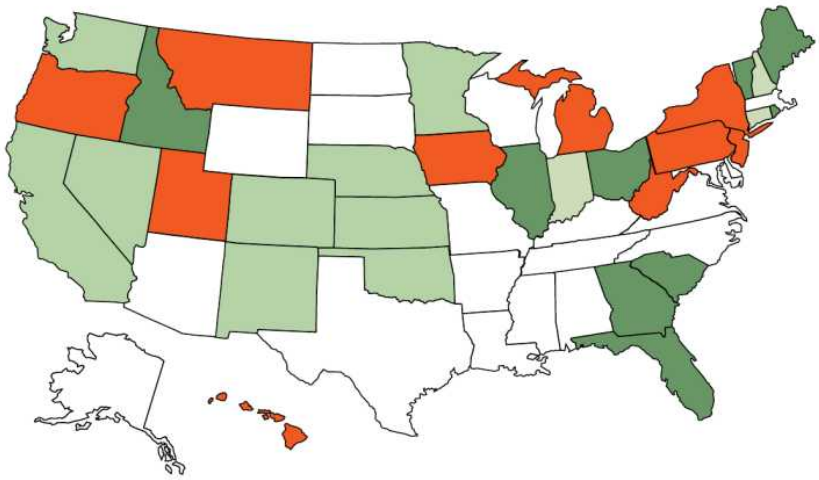
Since 2005, transportation agencies in the United States have completed more than 100 bridge projects using UHPC. From 2005 through 2014, transportation agencies completed 52 projects using UHPC. In 2015 and 2016 alone, agencies completed another 48, which shows an acceleration in the application of UHPC.

The New York State Department of Transportation is largely responsible for the increase in the number of projects. Fifty-six of the 100 projects that used UHPC before 2017 were constructed in that State. FHWA has created an interactive map that presents these and additional project information (see www.fhwa.dot.gov/research/resources/uhpc/bridges.cfm).

Using UHPC for connections has been the most common application. Ninety-five of the 100 projects built before 2017 used UHPC to connect prefabricated bridge elements.

Through the EDC initiative, FHWA tracks the deployment status of UHPC connections by the 50 State DOTs, the District of Columbia, Puerto Rico, the Virgin Islands, and FHWA's Federal Lands Highway Division. In January 2015, 12 highway agencies reported using UHPC connections, and by January 2017,

State Deployment of UHPC Connections (Demonstration Level or Higher)



States reporting that they have used UHPC connections as of January 2015 are shown in orange. Additional States reporting they have used UHPC connections since January 2017 are shown in medium green. States reporting an interest in using UHPC connections in the future are shown in light green. *Source: FHWA.*

Here, workers are placing a precast deck panel on a bridge.

the number had grown to 21 agencies. Also in January 2017, 14 additional agencies reported an interest in using UHPC connections.

Types of UHPC Connections

Agencies most frequently have used UHPC to connect precast deck panels together and to connect the panels to the girders. Shipping precast deck panels to the bridge site and connecting them onsite reduces the time to construct the deck compared with placing the bridge deck concrete at the bridge site. Offsite shop manufacturing also allows for the fabrication of high-quality deck panels. The bridge deck has extreme exposure to the environment and traffic, and the deck protects the rest of the bridge. Consequently, the durability of the deck panels and their connections is critical to the life of the bridge. For agencies that use protective wearing surfaces for these connections, the durability of UHPC can result in further savings in cost and time by reducing the need for protective wearing surfaces.

Agencies also have used UHPC to connect modular superstructure elements. With these elements, the girders and what will be the bridge deck are combined and fabricated offsite. The construction of a separate bridge deck on the girders at the bridge site is therefore eliminated.

Examples of modular superstructure elements include precast concrete girders or steel girders fabricated in pairs with the bridge deck attached; precast adjacent box girders; and deck bulb-tee girders. The connections between modular superstructure elements are deck-level connections, and the durability of UHPC has the same importance as it does for deck panel connections. With conventional concrete, the connections of adjacent box girders and deck bulb-tee girders can be susceptible to cracking along the length of the connection. Again, UHPC can provide a stronger connection that mitigates or eliminates this cracking.

In addition to *super*structure elements, highway agencies have used UHPC connections for prefabricated *sub*structure elements. Instead of casting the concrete for bridge abutments and piers in the field, the agencies have used abutments and piers composed of precast concrete elements that they connect in the field. Substructure connections generally have larger diameter reinforcing steel bars than superstructure connections. With conventional

This prefabricated modular steel girder superstructure element is ready for shipping to the bridge site.

Shown here are four adjacent precast box girders that will be connected using UHPC. *Photo: Eric Steinberg.*

This photo shows the placement of deck bulb-tee girders. *Photo: NYSDOT.*

concrete connections, the larger bars require correspondingly larger and more complicated connection details. Here again, agencies have used UHPC to reduce the size and complexity of the connections.

FHWA's Deployment Of UHPC

FHWA initiated UHPC research in 2001 and has taken an active role in delivering information on UHPC to highway agencies by providing technical publications and technical assistance to State DOTs.

To support the deployment of UHPC connections, FHWA published the *Design and Construction of Field-Cast UHPC Connections* (FHWA-HRT-14-084) in October 2014. This publication provides guidelines for the construction and testing of UHPC connections, and specific recommendations for designing and detailing the connections. For a full list of FHWA publications and research reports on UHPC, visit www.fhwa.dot.gov/research/resources/uhpc/publications.cfm.

In 2015, FHWA selected UHPC as one of the innovative technologies to deploy in EDC-3. Through the EDC initiative, FHWA offers UHPC workshops to State DOTs. The workshops provide an introduction to UHPC connections and cover the content of *Design and Construction of Field-Cast UHPC Connections*. The workshops include modules on the design, construction, and application of UHPC connections, as well as other applications of UHPC for bridges. Since March 2015, 23 highway agencies have hosted UHPC workshops. State agencies interested in hosting a UHPC workshop should contact their FHWA division office or Mark Leonard.

In addition, FHWA hosted six monthly public EDC webinars on UHPC, starting in March 2017 and ending in August 2017. The webinars featured an introduction to UHPC and presentations on the deployment of UHPC connections in Delaware, Georgia, Iowa, Minnesota (Hennepin County), New Jersey, and New York. FHWA recorded the webinars, and they are available for viewing at www.fhwa.dot.gov/innovation/everydaycounts/edc_4/uhpc_webinar_recording.cfm.

Through EDC, FHWA has projects in progress to update the agency's guidelines for UHPC connections and to develop a construction checklist for UHPC connections. These two publications are scheduled to be available early in 2018 and will be accessible through the EDC Web page on UHPC: www.fhwa.dot.gov/innovation/everydaycounts/edc_4/uhpc.cfm.

"Whether part of a major river crossing or a grade separation, the FHWA investment made in UHPC is now helping owners build bridges better and faster," says Joey Hartmann, FHWA's director of the Office of Bridges and Structures. "FHWA will build on this success by continuing to support the development and deployment of a program of technology and innovation."

Mark A. Leonard, P.E., is a structural engineer on the Structures Technical Service Team at FHWA's Resource Center in Lakewood, CO. Leonard provides technical assistance, training, and review services in the areas of highway structure design, maintenance, preservation, and inspection. He began his employment with FHWA in 2012 and has 28 years of experience as a structural engineer with the Colorado Department of Transportation. He has a bachelor of science degree in civil engineering from the University of Notre Dame.

For more information on FHWA's UHPC research activities, contact Benjamin A. Graybeal at benjamin.graybeal@dot.gov. For more information on FHWA's EDC deployment of UHPC, contact Mark A. Leonard at 720-963-3747 or mark.leonard@dot.gov.

These precast abutment elements will be connected using UHPC. *Photo: NYSDOT.*

Shown is the connection of a new precast pier cap to an existing column prior to placement of the UHPC. *Photo: Lafarge.*

Refueling America

by Diane Turchetta, Carter Purcell, and Sean Nyhan

FHWA is shaping the future of highway infrastructure by designating corridors across the country that provide charging and fueling stations for vehicles powered by electricity, hydrogen, propane, and natural gas.

Alternative fuel vehicles are now more common than ever. According to the 2017 *Fuel Economy Guide* published by the U.S. Department of Energy and the U.S. Environmental Protection Agency, consumers can now find a variety of alternative fuel vehicles on the market. With more than 23,000 public facilities located throughout the United States to charge and fuel those vehicles, they are becoming a more viable choice for commercial and passenger vehicles. However, a challenge remains: how can this market continue to grow without adequate infrastructure to keep these vehicles fueled and charged? For stakeholders waiting for alternative fuel vehicles to evolve from automotive novelties to ubiquitous commercial and passenger vehicles, a common refrain echoes out over the miles and miles of highways without adequate fueling stations: If you build it, they will come.

Signage for alternative fueling corridors, like these roadside signs marking the beginning of such a corridor in Minnesota, is poised to go up along sections of the National Highway System, increasing mobility and access for drivers of alternative fuel vehicles. *Photo: Minnesota Department of Transportation.*

Forecasts for sales of alternative fuel vehicles will likely fluctuate in the coming years depending on the steps taken by State and local officials to connect the dots between available fueling stations. After all, consumer research points to a direct connection between fuel availability and attitudes about alternative fuel vehicles. Take electric vehicles (EVs), for example. With recent improvements in battery technology, EV drivers can travel increasingly long distances on a single charge. But concern over both the availability and the convenience of access to charging stations may trigger a phenomenon known as range anxiety in EV drivers.

To address the missing pieces, the Federal Highway Administration is supporting a series of nominations to designate alternative fueling corridors along sections of the National Highway System. As part of the Fixing America's Surface Transportation (FAST) Act, FHWA has solicited submissions from State and local officials across the country to identify candidate corridors. According to the solicitation, the designations must identify the need for fueling infrastructure at strategic locations along major national highways to improve the mobility of passenger and commercial vehicles that employ electric, hydrogen fuel cell, propane, and natural gas fueling technologies across the United States. FHWA is also supporting testing technologies that may charge EVs while they are in motion on interstate highways (via electrically charged magnetic coils embedded in or on the surface of the pavement).

"The corridors developed by FHWA are an innovative way to improve infrastructure and mobility for alternative fuel users across the Nation," says Gloria Shepherd, associate administrator of FHWA's Office of Planning, Environment, and Realty. "By making these fuels accessible, FHWA also helps to promote U.S. energy security and strengthen our economy by reducing dependence on foreign oil."

Creating a National System

As part of the FAST Act, the U.S. Department of Transportation is required to identify aspirational goals to be met by 2020 for the deployment of domestically produced electricity, hydrogen, natural gas, and propane fueling infrastructure. One such goal is the incorporation of consistent signage throughout the corridor. To date, corridors in 35 States plus Washington, DC, have been designated as signage-ready, which means enough facilities exist on the corridor to warrant signage alerting drivers of the availability of alternative fueling stations.

The departments of transportation in Minnesota and South Carolina already have installed highway signage. The nascent Minnesota corridor located along I-94 has a handful of signs alerting motorists of the availability of alternative fueling stations. According to Timothy Sexton, construction and operations section director with the Minnesota DOT, the atmosphere at the DOT and among industry partners in the State has been enthusiastic. "It was actually pretty straightforward, [and] everyone was on board with the concept," Sexton says.

Other FHWA goals for alternative fuel corridors include consistency and convenience, reliability and performance, and enhanced coordination among and between the public and private sectors. Here's a closer look at what each of these goals entails.

Consistency and convenience. As it currently exists, the landscape of

Fuel Types in the Alternative Fuel Corridor Program

EV charging. A form of fueling for plug-in electric drive vehicles, EV charging involves pulling energy from an offboard power source. This category includes both hybrids (10–50 miles, 16–80 kilometers, on a single charge) and fully electric vehicles (60–300 miles, 96–482 kilometers). The market is strongest along the west coast, in the Northeast, and in Hawaii.

Hydrogen. This gaseous alternative fuel can come from natural gas and other types of renewable electricity. Hydrogen fuel cell electric vehicles power an electric motor by converting hydrogen to electricity. These vehicles can refuel in less than 10 minutes and perform on a single charge for more than 300 miles (483 kilometers).

Propane. This alternative fuel has been used in light-, medium-, and heavy-duty vehicles for decades. Consumers can either purchase propane vehicles from the manufacturer or convert an existing automobile. The fueling process is like pumping traditional gasoline, but there are currently fewer stations than EV stations. The market for propane vehicles is fragmented, with stronger markets in select States.

Natural gas. Natural gas is stored onboard a vehicle as compressed natural gas or liquefied natural gas. Compressed natural gas fuel systems transfer natural gas from the tank to the engine while reducing the fuel pressure. Liquefied natural gas fuel systems convert the liquefied fuel into gas before it is injected into the engine.

Roadside signage indicates to drivers which types of fueling stations are available in the corridor. *Source: FHWA.*

Alternative fuel types have unique infrastructure needs, as indicated by the diversity of nozzles shown here. *Photo: DOE Alternative Fuels Data Center, www.afdc.energy.gov.*

alternative fueling stations lacks a uniform geographic layout. Without consistency, consumers have little reason to trust that their vehicles will not run out of fuel before they could reach the next fueling station. The USDOT Alternative Fuel Corridor designations will ensure that drivers have access to alternative fuel facilities at consistent intervals across the Nation's highways. Designations are based on the criteria developed by FHWA related to the distance between facilities for each fuel type.

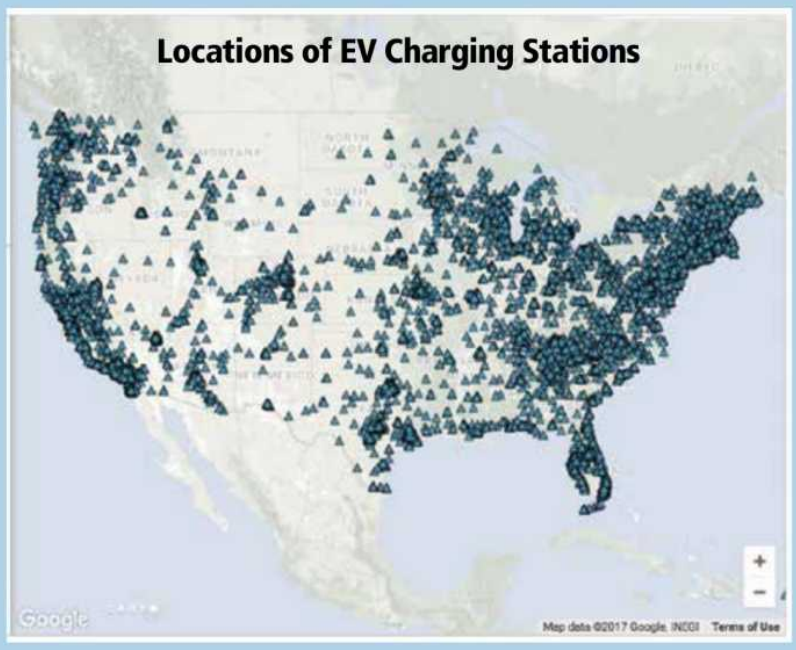
Reliability and performance. FHWA aims to ensure that travelers can navigate between destinations quickly and safely. Research shows that consumers place a high premium on the peace of mind that comes with reliable fueling stations, like those offered to gasoline and diesel powered vehicles.

Enhanced coordination of public and private sectors. For any fuel corridor to maintain consistency, agencies at the Federal, State, and local levels have to work together to continue a dialogue about the share of public and private sector investment in the infrastructure.

FHWA has designated portions of 55 corridors across 35 States, covering approximately 85,000 miles (136,794 kilometers) of the National Highway System, as the backbone of a national network of alternative fuel corridors. A nomination process in 2016 resulted in these designations, which led to collaboration among FHWA, USDOT's Volpe National Transportation Systems Center, the U.S. Department of Energy (DOE), and DOE's National Renewable

FHWA designated Alternative Fuel Corridors across the country for EVs. Several also exist in Hawaii (not shown here). Green routes indicate corridors designated as "signage ready." Orange routes indicate "signage pending" corridors. The difference between "signage-ready" and "signage-pending" designations is the maximum distance between fueling stations. *Source: FHWA.*

More than 16,000 EV charging stations exist nationwide, a higher number than for any other alternative fuel.
Source: DOE Alternative Fuels Data Center, www.afdc.energy.gov.



Energy Laboratory. Together, the agencies mapped all public EV charging, hydrogen, propane, and compressed natural gas (CNG) and liquified natural gas (LNG) stations located within 5 miles (8 kilometers) of the nominated corridors found on the National Highway System.

Other considerations for the alternative fuel corridors include the particular fueling methods employed. For the initial round of corridor designations, FHWA included both direct current fast charging (DCFC) facilities as well as Level 2 (240-volt charging) facilities. However, the second round request for designations only included DCFC, which allows for quicker charging than Level 2 facilities and charges at about 60 to 80 miles (96 to 129 kilometers) of range in 20 minutes. DOE is also considering the development of "extreme" fast charging, which can provide 200 miles (322 kilometers) of range in a little more than 15 minutes. As technologies improve, FHWA will revisit the parameters of new corridors to ensure they are meeting the most current needs of alternative fuel users.

Industry Partnerships Pave the Way

FHWA will have some help in meeting these goals. In addition to collaboration with DOE, State DOTs, and local agencies, FHWA is coordinating with industry stakeholders, hosting webinars in which numerous parties provide input, and attending industry events.

Industry participation is a necessity—after all, a highway is only as good as the vehicles that drive on it. As consumer interest in alternative fuels has grown, industry has responded. Automakers report that 11 percent of motor vehicle jobs in 2016 focused on alternative fuel and advanced technology vehicles. In addition, several industry stakeholders have expressed interest in adapting innovative power transfer technologies, such as recharging chips embedded in pavements to transfer power to vehicles, to U.S. highway design specifications.

Automobile manufacturers have continued to set ambitious goals to champion alternative fuel vehicles, such as Volvo's high-profile plan to produce only hybrid and electric-powered cars by 2019. But it is not just passenger vehicles fueling the industry. Although medium and heavy trucks make up only 4 percent of vehicles on the road, they account for about a quarter of U.S. fuel consumption, meaning commercial and freight needs are driving an important sector of potential new growth for alternative fuels.

Manufacturers' desire to produce for a growing market may be unsurprising, but what is more encouraging for the future of alternative fuel infrastructure is the enthusiasm stakeholders across the industry have in collaborating across public and private lines.

The idea of a cooperative network for alternative fuel vehicles is not an entirely new one. DOE's Technology Integration Program has fostered such connections in the industry for more than 20 years, building innovative partnerships and coalitions across the country to reduce U.S. reliance on petroleum. Currently, nearly 100 local Clean Cities coalitions span the country. A group may include local businesses, fuel providers, community organizations, and nonprofits, working together to educate their communities about alternative fuels, seed local market growth, and reach petroleum savings targets.

Fun Facts: Putting Alternative Fuels on the Map

- The United States is home to nearly 24,000 alternative fuel stations. Compare that to approximately 156,000 public retail gasoline stations.
- A 2016 public opinion poll by the National Renewable Energy Laboratory shows EVs are top-of-mind when it comes to alternative fuels: 43 percent of respondents said it was the best option to replace traditional fueling vehicles for personal use. Respondents chose natural gas as their second choice at 24 percent.
- Alternative fuels are growing internationally. The United Kingdom, France, and India are among countries with plans to transition to selling only alternative fuel vehicles by 2050, while China recently announced a plan to set its own target.

Clean Cities coalitions, plotted here around the country, bring together local businesses, fuel providers, vehicle fleets, State and local governments, and community organizations to cut petroleum usage in their communities. *Source: DOE.*

One accomplishment of the group, which should not be underestimated, is the knowledge sharing that accompanies 20 years of data surrounding alternative fuel infrastructure. The National Renewable Energy Laboratory collects a robust volume of data from across the country. For example, at certain EV stations, charging station networks make status reports on a nightly basis. For other fuels, industry partners make regular calls to stations to determine availability—all to ensure that the data and maps are as accurate and up to date as possible. DOE's Alternative Fuel Data Center Web site (www.afdc.energy.gov) uses these data to map thousands of stations across the country. In addition, the DOE Vehicle Technologies Office works to make data accessible to consumers through online information campaigns and a station finder app.

Taking Shape: The First Installations

In 2017, South Carolina became one of the first States to add signage to an existing corridor, along a stretch of I-26 outside Charleston. Several other corridors in the State also have been designated as ready for signage. The Palmetto Clean Fuels coalition, with stakeholders as diverse as Piedmont Natural Gas, Nissan, Plug in Carolina, and the American Lung Association, estimates that South Carolina achieves an annual savings equivalent to more than 3.7 million gasoline gallons (14 million liters) in petroleum savings. Within State lines, the coalition counts more than 600 alternative fuel charging stations.

"This sort of local data about charging stations and alternative fuel benefits is crucial for public awareness and buy-in to new technology," says Linda Bluestein, co-director of National Clean Cities. "It is also what has enabled FHWA's corridor program to 'connect the dots' on alternative fuel infrastructure. Clean Cities coalitions collect data on thousands of charging stations from their stakeholders around the country. Without that kind of local knowledge, it wouldn't have been possible to identify the FHWA corridors."

The Upper Midwest, home to the first corridor signage along I-94, proves that these relationship models are built to last when it comes to alternative fuel corridors. The I-94 corridor spans over 1,500 miles across five States (Illinois, Indiana, Michigan, Minnesota, and Wisconsin) in a path called the "Great Lakes Zero Emission Corridor." The five State DOTs, the city of Detroit, FHWA, and DOE joined with nongovernmental forces, including nonprofit and industry coalitions, such as the Drive Electric Minnesota advocacy group.

Officials overseeing the project hope that the partnership efforts in Minnesota can serve as a kind of incubator for the early stages of creating alternative fuel corridor infrastructure. "It takes a village to build a program like this," says Wendy Dafoe, senior project manager at the National Renewable Energy Laboratory.

Connecting the Dots

Although alternative fuel corridors are still a new concept, the marketplace has experienced rapid growth—with no signs of stopping. Dozens of corridors await additional fueling stations in order to qualify as ready for signage. The corridors themselves are a tool to add more fueling stations around the country, strengthening a growing industry, and ensuring that this sector of the transportation market will have a strong future.

"It used to be, these charging stations were scattered dots on a map," says Dafoe. "Now we see more cohesive clusters and corridors coming together. The industry has really grown up, and it's an exciting moment to see the public and private sectors being smarter about working together to take the next step to build out these corridors."

FHWA has put in place a series of goals to continue this work, including identifying barriers to installing more fueling facilities, locating sources of funding, promoting strong regional and national collaboration, and increasing cooperation with DOE's Technology Integration Program and the National Renewable Energy Laboratory.

Current alternative fuel vehicle owners and prospective owners may not know what to expect once on the road, but the landscape is changing. Stakeholders in nonprofits, private industry, State and local transportation agencies, DOE, and FHWA are developing a robust infrastructure for these vehicles. Over the coming months and years, State DOTs are expected to expand sign installations along corridors throughout the country.

"[Alternative fuel] corridors support regional cooperation in strengthening the use of alternative fuels around the country, and FHWA looks forward to working with our local and national partners to develop them further," says FHWA's Shepherd.

The ultimate goal is to make sure that the driving public is aware of where alternative fuel facilities are located on the Nation's highways so there will be no more of an uncertainty than with a traditional gasoline vehicle. This innovative approach to a new marketplace will give a larger platform to alternative fuel technology, reducing the Nation's petroleum use and dependence on foreign oil, and strengthening U.S. transportation infrastructure for the 21st century.

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Carter Purcell is a communications professional with experience across a range of environmental issues in transportation, energy efficiency, and agriculture. She works for the Cadmus Group, supporting marketing for FHWA's Office of Planning, Environment, and Realty. She has a bachelor's degree in English from Columbia University.

Sean Nyhan is a strategic communications specialist who works closely with transportation partners like USDOT, FHWA, and the Association of Clinical Research Professionals through his position at the Cadmus Group. He is a former reporter who covered environmental issues in New Jersey. Nyhan has a master's degree in strategic communication from George Mason University.

For more information, see www.fhwa.dot.gov/environment/alternative_fuel_corridors and http://altfueltoolkit.org, or contact Diane Turchetta at 202-493-0158 or diane.turchetta@dot.gov.

South Carolina installed its first signage in summer 2017, following Minnesota to become the second labeled corridor. *Photo: SCDOT.*

READY FOR TAKEOFF

by James Gray, Bryan Cawley, and Alicia Sindlinger

Unmanned aerial systems are taking flight in highway transportation. Here's a bird's-eye view at how and where the industry is using them.

Demand on the Nation's transportation network continues to rise. Over the next 30 years, the population of the United States is expected to increase by nearly 70 million people. Freight volume is likely to increase by more than 40 percent during that same timeframe. To continue to meet traveler expectations for a safe and reliable transportation system, transportation agencies are looking for better ways to safely collect more precise and timelier information. Unmanned aerial systems could serve in many capacities to help reach these goals and keep the country moving.

(Above) The Federal Highway Administration and State agencies are exploring the best ways to incorporate small unmanned aerial systems into their transportation toolbox. Here, a member of a flight crew contracted by FHWA checks the camera on a small drone prior to flight.

Using unmanned aerial systems in transportation applications can improve system performance, increase efficiency, and enhance safety by providing information from a different perspective. The method of collecting information using unmanned aerial systems is generally safer, less expensive, and less time consuming. For example, transportation agencies might use them for aerial photography to support surveying and bridge inspection efforts, which are

two time-consuming and expensive tasks if done by traditional methods.

An unmanned aerial system includes an unmanned aerial vehicle, a system for data collection/communication, and a ground-based operator. More simply put, the system includes an unmanned aircraft and the equipment necessary for the safe and efficient operation of that aircraft with capabilities for data collection. An unmanned aircraft vehicle, often referred to as a drone, is defined by statute as an aircraft that is operated without the possibility of direct human intervention from within or on the aircraft (Public Law 112-95, Section 331(8)). Drones come in many shapes and sizes. Some come with single or multiple rotors and others come as fixed-wing designs.

Rapid technological advances are making unmanned aircraft more efficient and accurate, and more readily available and affordable. A variety of these aircraft are now available with lighter, longer lasting, more powerful batteries; longer flight times; larger payloads; and more sophisticated flight control software. Combined with advances in digital camera technologies, smaller remote sensing options, and new developments in computer software, the possibilities for building a system and meeting specific needs are immense.

According to the U.S. Department of Transportation's *Beyond Traffic 2045* final report, annual worldwide spending on unmanned aircraft is expected to double to $11.5 billion over the next decade. The ready availability of unmanned aircraft, along with their powerful capabilities and the technological advances, are fueling an increased interest in their use for a variety of purposes in highway transportation.

History of Drones: Birthed from Military Use

In the United States, infrastructure-related applications of unmanned aircraft gained popularity after their use became common in military operations, especially for intelligence, surveillance, and reconnaissance. Military uses started even before the 20th century began.

According to author Ian G.R. Shaw, "In 1896, Samuel P. Langley developed a range of steam-powered aerodromes, unpiloted aircraft that were flown successfully along the Potomac River near Washington, DC. In those ninety-second flights, a glimpse of the future could be seen in the hovering aerodrome."

Aerial surveillance emerged as early as the 1898 Spanish–American War when the U.S. military fitted a camera to a kite, producing one of the first aerial reconnaissance photographs. However, it was not until the early 2000s in the combat zones of Iraq and Afghanistan that unmanned aircraft saw a significant increase in use. As of late 2004, unmanned aircraft had flown more than 100,000 flight hours in support of Operation Enduring Freedom and Operation Iraqi Freedom.

In fiscal year 2000, the U.S. Department of Defense's (DOD) funding for drones was around $284 million (note this was before the terrorist attacks on September 11, 2001). Between 2002 and 2010, the U.S. military's inventory of drones increased forty-fold to a fleet size of some 11,000 drones, hundreds of which are weaponized. In fiscal year 2017, the military allocated approximately $4.61 billion for drone-related spending.

According to DOD, unmanned aircraft have proven to enhance situational awareness, reduce human workload, improve mission performance, and minimize risk to both civilian and military personnel. All this is at a reduced cost compared to more traditional methods of conducting intelligence, surveillance, and reconnaissance. Because of these demonstrated benefits, DOD estimates that the prevalence and uses of unmanned systems will continue to grow at a dramatic pace.

This small unmanned aircraft, disassembled and stored in a box, is one that FHWA's Western Federal Lands Highway Division has tested. It is a basic, fixed mono-wing aircraft and has few moving parts.

The same drone, assembled and on the ground after landing.

Uses in Transportation

Unmanned aircraft have many potential uses in highway transportation—from inspection of construction and existing infrastructure assets to law enforcement and operations. According to a March 2016 survey by the American Association of State Highway and Transportation Officials (AASHTO), 33 State departments of transportation have or are exploring, researching, testing, or using this technology to inspect bridges and assist with clearing vehicle crashes, among other innovative applications. What follows is a closer look at how some States are using unmanned aircraft.

Construction. Drones can collect real-time environmental data (for example, air quality and temperature), survey difficult and inaccessible terrain, and track real-time construction progress. Imagery and data collected by unmanned aircraft have proven to be useful tools in design and preconstruction workflows and monitoring construction sites, among other uses.

In New York, the department of transportation reports an increase in contractors using unmanned aircraft for quantity calculations and routine construction monitoring, and to support model creation for automated machine grading.

Law enforcement and emergency response. Several law enforcement agencies are testing or using these systems at vehicle crash scenes. Using unmanned aircraft enables investigating officers to scan and document physical evidence, roadway dimensions, and characteristics more quickly than if they had to measure the evidence using traditional devices such as measurement wheels. They are able to clear crash scenes more quickly and restore normal traffic flow, resulting in fewer traffic delays related to crashes.

In Georgia, the Gwinnett County Police Department first used a drone in 2016 to investigate serious traffic crashes. The department began with two certified officers flying it over incident scenes to take pictures and video. The technology gives them a more complete view of the scene and saves time compared to waiting for a fire department ladder truck or using the police helicopter. The department hopes to have additional officers obtain their certifications and to extend its use of unmanned aircraft for other purposes.

Traveler information and data collection. Several types of traffic studies and research data acquisition efforts are well-suited for aerial surveillance by unmanned aircraft. A recent project by FHWA's Office of Safety Research and Development used unmanned aircraft to collect data on lane choice and final destination for vehicles entering the study area. This particular application involved recording a 3-mile (4.8-kilometer) length of suburban freeway in Florida and three interchanges in Washington State. FHWA used unmanned aircraft systems to collect video from these areas to provide data for the analysis of driver behavior relative to lane selection along freeway segments between entrance and exit ramps. The technical results are available in the project report *Enhancing*

The Minnesota Department of Transportation used this unmanned aircraft to test the drone's inspection capabilities on the Arcola Bridge near Crystal Bay, MN. Typically, this bridge is inspected using rope access because of its height. *Photo: Minnesota Department of Transportation.*

The drone proved to provide the level of detail needed to detect defects. In fact, the elements that are difficult to access through traditional methods were readily visible using the unmanned aircraft. *Photo: Minnesota Department of Transportation.*

The zoom lens on the drone's camera captured a high level of detail without having to position the unmanned aircraft too close to the bridge. *Photo: Minnesota Department of Transportation.*

Safety and Operations at Complex Interchanges with Integrated Signing, Marking, and Geometry.

Maintenance and infrastructure inspection. FHWA requests that States visually inspect and inventory all bridges on public roads with a span greater than 20 feet (6 meters) once every 2 years. These mandatory biennial bridge inspections are important for assessing the condition of bridges. However, some inspections require extensive climbing or equipment, which needs significant preparations and time to ensure safety. Using unmanned aircraft, bridge inspectors can gain supplemental information to support the condition assessment of critical elements of the bridge.

In 2015, the Minnesota Department of Transportation conducted a demonstration project using an unmanned aircraft for bridge inspection. The project team investigated use of the technology on four bridges located throughout Minnesota. The team evaluated the technology's effectiveness as applied to bridge inspections based on field results. Overall, the study team observed that the safety risk to inspection personnel and the public is very low with the use of unmanned aircraft. The team also concluded that drones can provide a cost-effective way to obtain additional detailed information that otherwise might not be visible during routine inspections because of limited accessibility. For more information, visit www.dot.state.mn.us/research/TS/2015/201540.pdf.

The Ohio Turnpike and Infrastructure Commission and Ohio Department of Transportation also are testing the use of drones to inspect bridges. In September 2016, the agencies demonstrated the technology on a turnpike bridge outside Fremont, OH. The demonstration showed how unmanned aircraft can supplement traditional inspection methods. For example, traditionally, inspectors sometimes climb the bridge using harnesses to visually access the underside of the bridge or require an under-bridge inspection truck parked on the outside lane or shoulder of the road with barrels set up to redirect traffic. If deterioration is identified using the unmanned aircraft, these traditional methods are then employed to get a hands-on inspection to verify the extent of the condition. The goal is to implement the technology throughout the State.

The Washington State Department of Transportation used a drone to capture video footage for this up-close view of a slope on State Route 503 that requires stabilization. *Photo: Washington State Department of Transportation.*

In Washington State, heavy rainfall in March 2017 caused a major debris slide onto a section of State Route 503 east of Woodland, WA, blocking the highway. The threat of additional falling rocks and debris prompted an emergency slope stabilization project. Geotechnical engineers with the Washington State Department of Transportation used unmanned aircraft to inspect the hillside and to help develop a permanent repair. Conditions were too dangerous to have the geotechnical engineers access the site themselves.

"We're really just scratching the surface of the untapped ways we can use unmanned aircraft for transportation purposes," says Hari Kalla, acting associate administrator for the Office of Planning, Environment, and Realty at FHWA. "Many States and disciplines are still exploring how and whether unmanned aircraft can help them achieve their goals."

Challenges to Implementation

Successfully and safely using unmanned systems requires trained and skilled staff, as well as an understanding of the technology's abilities and limitations, and its supporting information-gathering equipment. Effective use of the capabilities requires highly trained unmanned vehicle operators, sensor and payload operators, and analysts to process, analyze, and disseminate the data collected.

Although the technology is advancing at incredible rates, limitations still exist. For example, the duration of an infrastructure inspection can last from hours to weeks but existing drone batteries have a relatively short charge life and limit actual time of inspection to less than an hour.

Staff also must understand and operate the equipment within the regulatory boundaries of the National Airspace System, Federal Aviation Administration (FAA), and State and local laws. These complexities have challenged implementation by transportation agencies.

From 2014 through 2016, the National Conference of State Legislatures (NCSL) brought together State legislators, legislative staff, and private industry representatives to discuss unmanned aircraft systems. The group worked to develop policy issues and options related to the use of small drones for agriculture, insurance, natural resource management, law enforcement, and a variety of other purposes. Discussion focused on concerns about privacy, safety, and business and economic interests. In a white paper titled *Taking Off: State Unmanned Aircraft Systems Policies*, the group provided highlights of Federal actions and a comprehensive look at State legislative action addressing unmanned aircraft.

According to NCSL, beginning in the 2013 legislative session, State lawmakers considered many pieces of legislation addressing unmanned

aircraft. As of July 2017, 40 States have enacted laws and an additional 3 States have adopted resolutions. Common issues addressed in the legislation include defining unmanned aircraft systems, unmanned aircraft vehicles, and drones; their uses by law enforcement and other State agencies; their use by the public; and regulations for their use.

In 2016, the FAA finalized the first operational rules for routine commercial use of small unmanned aircraft systems (Title 14 CFR Part 107). The rule went into effect on August 29, 2016. The provisions aim to minimize risks to other aircraft as well as people and property on the ground. The regulations require pilots to keep unmanned aircraft within visual line of sight. Operations are allowed during daylight and during twilight if the drone has anticollision lights. The new regulations also address height and speed restrictions and other operational limits, such as the prohibition of flights over unprotected people on the ground who are not directly participating in the unmanned aircraft operation. In addition, the rule requires that the person actually flying a drone must be at least 16 years old and have a remote pilot certificate with a small unmanned aircraft rating, or be directly supervised by someone with such a certificate. For more information, visit www.faa.gov/uas/media/RIN_2120-AJ60_Clean_Signed.pdf.

FHWA and Partners Evaluation of Drones

In 2013, FHWA's Exploratory Advanced Research Program conducted a literature scan of research completed from 2006 to 2013 and focused on autonomous micro unmanned aerial vehicles for transportation applications. The scan provided background information to increase researchers' knowledge and understanding of the topic, and contributed to the process of identifying priorities and opportunities for strategic investment in further research.

Currently, AASHTO is conducting a domestic scan of unmanned aircraft technology in highway construction and maintenance. Researchers are recording users' initial investments, long-term and short-term plans for agency use of the technology, disposition of data collected, device performance in varying environmental conditions, and other practical assessments. The purpose is to visit the current adopters to document: (1) how they are using drones (for example, for inspection, inventory, survey, or other purpose); (2) why, how, and where they are using the technology; and (3) the way they are storing data.

The scan will improve understanding of the technology as well as benefits and the return on investment. The scan and its resulting report will help accelerate national deployment by demonstrating the technology's usefulness and best practices. The scan also will provide information concerning where additional research and development are needed to support increased use of this technology.

In addition, FHWA's Western Federal Lands Highway Division has built a strong business case for using unmanned aircraft as a more effective means to obtain critical topographic information used for many highway designs and to calculate material quantities. To make the business case for procuring the technology, FHWA started by identifying the data requested by the division's design and construction customers, and then identifying the most appropriate means of gathering or developing that data. One of the major needs of the design phase is topographic data. Designers use topographic data to lay out the alignment, grade, and side slopes of the road project, and then to calculate construction quantities.

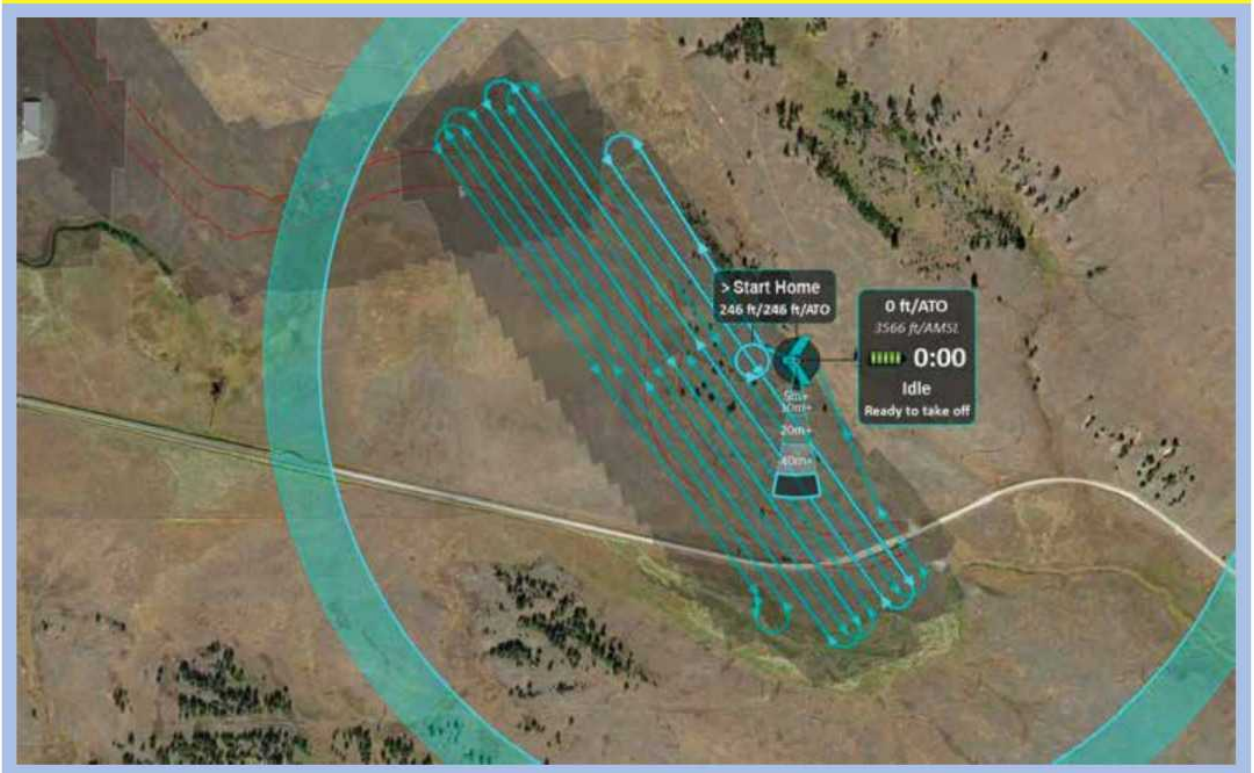
Currently, Federal Lands Highway (FLH) has three UX5-HP fixed-wing unmanned aircraft and a DJI Phantom 4 Pro, and several FLH employees have obtained their FAA pilot certificates. The FLH offices conducted test and production flights in 2017 and are now developing their policies and procedures for unmanned aircraft operations.

The Western Federal Lands Highway Division conducted a test project for using small unmanned aircraft during construction to relocate and reconstruct Pleasant Valley Road in Flathead County, MT. The project site is approximately 30 miles (48 kilometers) west of Kalispell, MT, in the Lost Trail National Wildlife Refuge. The division scheduled two flights for the project, one prior to construction in May 2016, and the second after construction in June 2017.

The division compared the data from the first flight (May 2016) to previous aerial light detection and ranging (LiDAR) data, and the results showed nearly identical accuracies. The division will use the additional data collected during the June 2017 flight to compare quantities calculated using the unmanned aircraft survey with those using typical survey procedures. If the results are within acceptable tolerances, the concept will prove valid, and the division may look at moving forward to develop its own unmanned fleet.

"I see so many potential uses for unmanned aircraft at the division,"

A contracted flight crew for FHWA sets up survey controls for a 2016 drone test flight in Montana.



Software capabilities used for the FHWA tests include advanced mission planning and drone control during flight. This software-generated image shows the unmanned aircraft's flight path.

says Bill McQuiston, senior highway designer and unmanned aircraft vehicle pilot/technician at the Western Federal Lands Highway Division. "The enthusiasm I am seeing for this type of advanced technology is contagious, and the possibilities unlimited."

Reaching New Heights

Interest in using unmanned aircraft for transportation purposes goes well past the borders of the United States. The World Road Association-PIARC is also documenting international use of drones with a focus on low- and middle-income countries. A final report and presentation will be available on the World Road Association-PIARC's Web site at www.piarc.org/en.

With no sign of interest in drones dissipating any time soon, FHWA continues to work to advance and define the role of unmanned aircraft in transportation applications. The agency has several activities currently in the planning stage related to market readiness. Activities include technical briefs that provide comprehensive guidance needed to assist transportation agencies and local governments in effectively using the technology; information-sharing workshops to disseminate hands-on knowledge, lessons learned, and best practices taught by champion States and subject matter experts; and a Web site to house all applicable information.

"The benefits of unmanned aerial systems far outnumber the challenges to implementation," says Thomas Everett, associate administrator for the FHWA Office of Infrastructure. "We've seen what's possible as testing has been underway across the country, and we're looking forward to transportation agencies realizing the safety, time, and cost savings compared to using traditional practices for these transportation applications."

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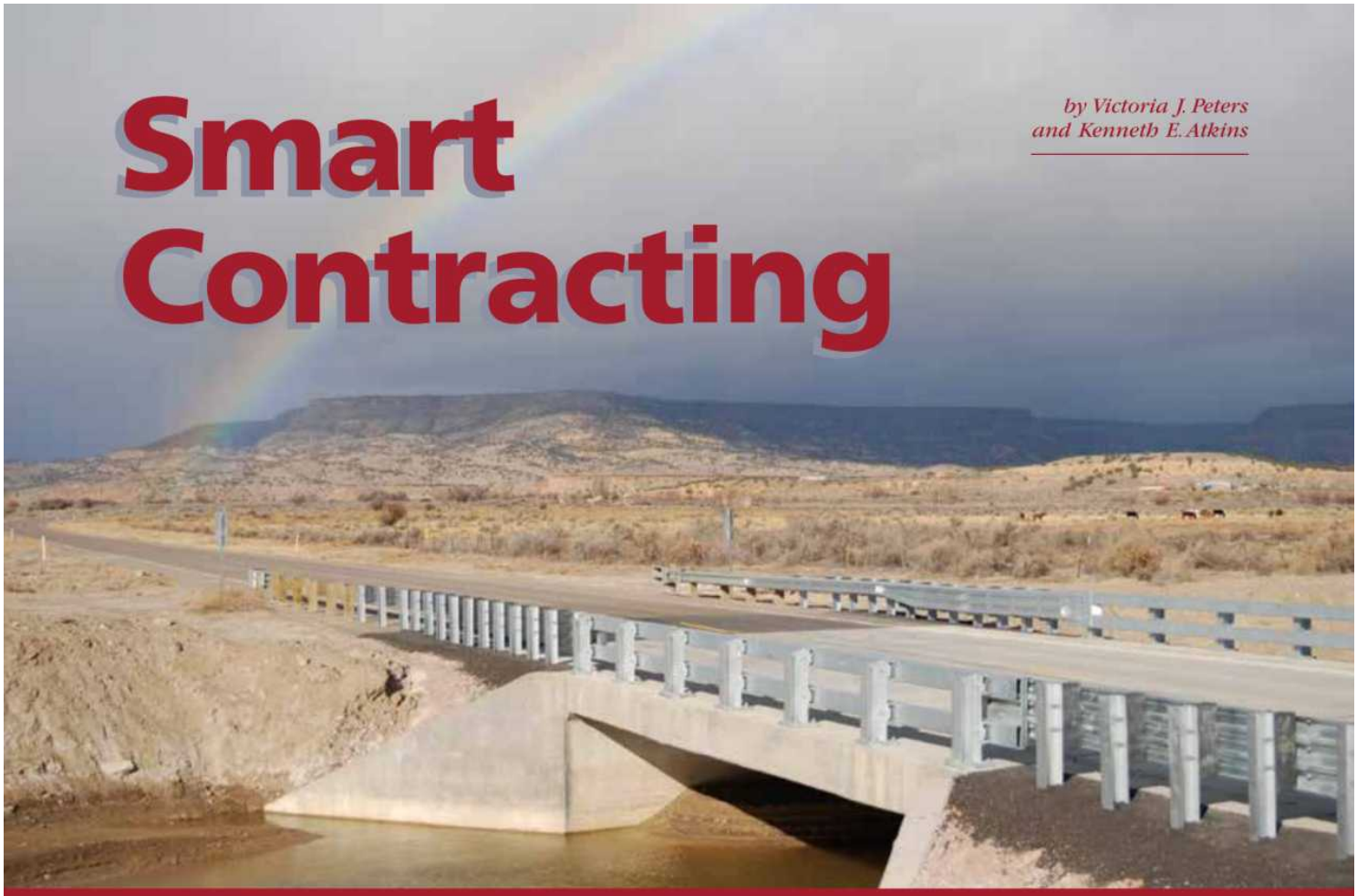
Smart Contracting

by Victoria J. Peters and Kenneth E. Atkins



Today, project delivery requires better and faster ways of doing business. One way is to use the construction manager/general contractor method of procurement. Here's how it works.

"Competent men in every position, if they are doing their best, know all that there is to know about their work except how to improve it," wrote author and scholar W. Edwards Deming in *Out of the Crisis*. If this sounds like a challenge, it should.

As budgets become tighter and governments are faced with deciding how to better spend public funds, transportation agencies have a responsibility to improve their work. Specifically, deteriorating infrastructure nationwide and increasing population create pressure to move projects more quickly from design to construction. One way for owners such as transportation agencies to improve is to lead their departments away from traditional, more costly methods of contracting.

All major capital projects involve intrinsic risks. Today's risks can stem from political or economic changes, climate impacts, technological changes, new materials, environmental issues, and many more. Traditional risk-transfer contracting models are proving inadequate to deal with these 21st century risks.

Often, the traditional design-bid-build (that is, low-bid) method is hindered by project delays, as well as paying for the risks versus strategizing as a team early on about how to minimize them. Traditional low-bid designs often build in risk, but this costs the owners and results in reducing or de-scoping the project. Moreover, in traditional contracting models, the owner owns the design and therefore is responsible for the cost of any errors or omissions encountered during construction.

Dealing with risks requires rethinking established practices and changing individual mindsets. In terms of measurable cost and time savings, nontraditional procurement methods—commonly known as alternative contracting methods (ACMs)—can benefit transportation programs substantially by offering several advantages that result in flexibility in project delivery.

(Above) Rinconado Bridge, seen here under a rainbow, was one of the projects that the Pueblo of Acoma in New Mexico constructed using the CM/GC procurement process. The project's owner called the experience "eye-opening" because of the innovation and teamwork that resulted from using CM/GC. *Photo: Pueblo of Acoma.*

Early Contractor Involvement

Albert Einstein once said, "We can't solve problems by using the same

kind of thinking we used when we created them."

Above all, project owners need to think critically to solve problems. Early contractor involvement, fueled by ACMs, is the key to improved thinking and hence better project planning and design. Achieving these results requires removing transportation industry fears of involving a contractor "too early" in the process. Ultimately, early contractor collaboration results in smart construction, transportation benefits, and life-saving improvements delivered faster and more efficiently, along with added value to the owners, as pointed out by the National Cooperative Research Program (NCHRP) in Report 787, published in 2014. When used early in the planning and design phases, ACMs outshine design-bid-build in harnessing contractors' technical expertise and construction management experience.

Departments of transportation can achieve remarkable time savings through early partnering and collaboration between the contractor and the entire project team. In fact, strategically employing ACMs offers the greatest opportunity to fast-track construction. To illustrate, ACM procurement can deliver projects reliably up to 50 percent faster than traditional contracting methods. In turn, this saves the owners money, according to a 2016 Federal Highway Administration webinar, "Quantification of Cost, Benefits and Risk Associated with Alternative Contracting Methods and Accelerated Performance Specifications."

According to NCHRP Report 787, the most effective type of ACM for mitigating project risks is the construction manager/general contractor (CM/GC) delivery method. Enhanced results from using CM/GC arise from collaborating early and sitting down often with the entire project team, including the owner, designer, independent cost estimator, and subcontractors. It is important to note that the subcontractors are not traditional low-bid subcontractors. On the contrary, the subs are preselected with the contractor's original proposed team. In other words, CM/GC, if used optimally, requires that subcontractors in each specialty area be present from the project's inception and available to assist in the development of the project.

Construction Manager/ General Contractor

The first contract phase of the CM/GC process is design, commonly referred to as the preconstruction phase. The preconstruction phase enables the project owner to work with a designer and contractor to identify risks, provide cost projections, and refine the project schedule. Project risks then can be mitigated through several options. Working together, the team can develop innovative design options based on contractor input using optimum means and methods, minimize schedule impacts using contractor input on effective phasing, or agree to share risks when the team is uncertain if the risk would actually be realized.

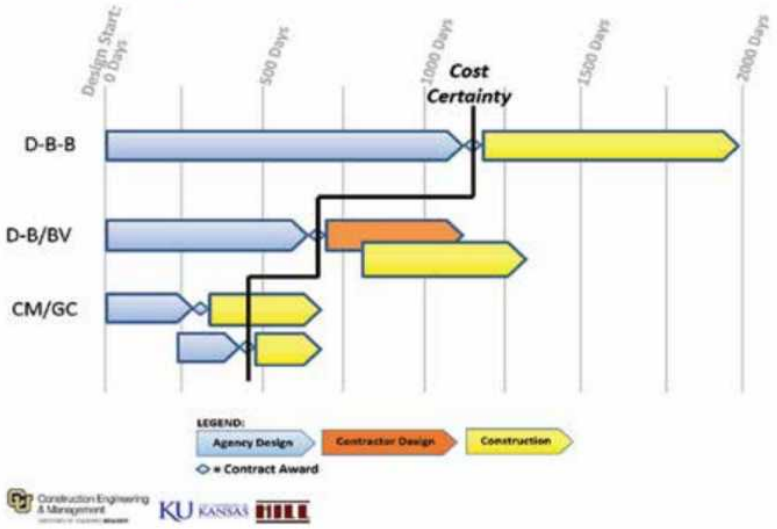
Average Duration Under Various Contract Methods for Projects Between $10 Million and $50 Million

Contract Method	Mean Cost ($)	Mean Project Duration (Days)	Mean Agency Design Duration (Days)	Mean Construction Duration (Days)*
D-B-B $_{(n=34)}$	$21,188,585	2,130	1,139	818
CM/GC $_{(n=10)}$	$23,912,981	662	281	349
D-B/BV $_{(n=10)}$	$18,604,503	1,420	638	639

**Note: "Construction Duration" for design-bid/best value projects includes design-builder design and construction (D-B contract duration).*

The CM/GC contracting method increases the speed of project delivery over other methods such as design-bid-build (D-B-B) and design-build/best value (D-B/BV). This graph compares the durations of projects with similar initial costs (as shown in the column for mean cost) and does not indicate the final price of the projects. The subscripts for each contract method indicate the number of projects used to gather the data. *Source: FHWA TechBrief HRT-17-100.*

Timing of Award Under Various Contract Methods for Projects Between $10 Million and $50 Million



Alternative contract methods like design-build/best value (D-B/BV) and CM/GC enable transportation planners to determine the cost certainty faster than the traditional design-bid-build (D-B-B) method. Cost certainty is the point at which the contractor provides a firm price for the project to the owner. For CM/GC, cost certainty is known after the cost for the last construction package has been agreed on. The figure shows two packages for illustrative purposes. *Source: FHWA TechBrief HRT-17-100.*

Pueblo of Acoma

Another project that the Pueblo of Acoma built using CM/GC was the parking lot for the American Legion Post 116 military veterans' building, shown here.

In CM/GC, the owner holds two contracts, one with its designer and one with its contractor. This varies from design-build, where the designer and contractor are united contractually. CM/GC enables the project owner to retain complete control of the design because the designer works directly for the owner agency. More important, this phase enables the owner to have input from the builder prior to making costly design decisions.

Perhaps the most important feature of CM/GC is the way this contracting method encourages, allows, and even requires innovation during the design process. Unquestionably, CM/GC incentivizes innovation to a greater extent than any other delivery system. What makes this possible is the owner, designer, and the contractor's team coming together at the project's conception.

This early relationship facilitates critical thinking because the intensity of the design effort is focused on planning construction versus producing plans. This focus ultimately leads to smart engineering—and innovations—as well as defining the true problems prior to construction. By generating innovations, CM/GC provides improved quality and performance—"smart construction."

Furthermore, CM/GC generates measurable overall project savings because the owner, contractor, subcontractors, independent cost estimator, design consultants, and stakeholders work cooperatively to develop and maintain an aggressive and cost-effective schedule, and to minimize project risks or to assign them to the party best equipped to mitigate those risks. The schedule and budget drive the project and all project decisions, not the other way around.

In other words, when decisions are being made, the team needs to ask whether the decision will contribute to bringing the project in ahead of schedule and under budget. If the answer is no, then it is not a good decision. In short, design details do not drive the weekly team meetings, the schedule and budget do.

CM/GC Success Story: Pueblo of Acoma

"After engaging in CM/GC, it's now my preferred delivery method," says Gregg Hostetler, P.E., project leader for the Acoma CM/GC design and senior vice president and senior structural engineer with Infrastructure Engineers. "As a matter of fact, I struggle to get enthusiastic about doing it any other way!"

In 2015, the Pueblo of Acoma in New Mexico decided to bundle nine construction projects under a single CM/GC contract in order to deliver the projects rapidly and create an economic stimulus package for the local community. The projects ranged from simple repair and stabilization of a retaining wall to full-depth roadway reconstruction. In addition to the various types of projects, multiple funding sources and stakeholders added to the complications involved in managing the project.

The team kicked it off in January 2016 with the goal to stretch the existing funding by capturing savings gained through innovations and risk reductions. The team started without designs and with environmental clearance for only one project. The suite of projects was developed using multiple early work packages in an effort to meet an accelerated schedule of 18 months. The team broke ground on the first project on May 12, 2016.

The Pueblo of Acoma achieved $1.15 million in cost savings out of a $6.9 million budget. Stretching this budget through smart engineering and innovations resulted in additional projects, which included (1) asset inventory and management for automated tracking of road maintenance, (2) equipment training for public works staff, and (3) an additional 3.2 miles (5 kilometers) of full-depth reconstruction of Pinsbaari Drive. The team targeted 30-percent savings on qualifying projects.

"Using the construction manager/general contractor method of project delivery for the first time has been an eye-opening experience," says David Deutsawe, interim public works director of the pueblo's Planning and Engineering Department. "The pueblo experienced true innovation and teamwork at the table with the designer and contractor. This dynamic allowed for full interaction from each member." Not only did this bring innovations, he adds, but it also resulted in smart construction.

Additional Advantages Of CM/GC

CM/GC has the power to deliver early work packages, ensuring that construction is underway (in some cases) as early as 2 weeks after a notice to proceed. Early work packages can be broken into such items as construction of retention ponds, partial clearing and grubbing, and ordering of long lead items (such as structural steel and drainage structures). In effect, these early work packages become a valuable tool for constructing shovel-ready portions of a project. Early work packages also hand the team an initial short-term win, which creates momentum.

In addition, CM/GC gives the owner and the team the flexibility

to stretch the project scope, within the available budgets. In effect, CM/GC enables the team to deliver more project for the money. As shown in the Acoma project, this is accomplished through the CM/GC team working diligently to achieve measurable risk reductions and innovations.

Moreover, CM/GC acts as a catalyst for establishing trust and interdependence by building teams of highly specialized, valued, and cooperative professionals, all having an equal seat at the owner's table. These team members are open to each other's ideas, professional opinions, and reservations. To illustrate, the Pueblo of Acoma's contractor proposed an alternate design to the one that the designer had in mind and was invested in. Instead of rejecting the idea, the designer embraced it. When the level of trust and cooperation is high, then the partnership is strong.

Another Success Story: Osceola County

The use of alternative contracting methods by Osceola County in Florida succeeded in the face of crushing, wide-ranging opposition from citizens, the county commission and staff, and local subcontractors. The opposition was because CM/GC was new to the county and unproven there, leading to an industry aversion to straying from the traditional low-bid contracting method. The county overcame the opposition by proving that the new delivery method worked.

Within one year of kicking off the new CM/GC system, construction of 11 major roadway segments was ready to begin. This delivery method achieved 55 times the production rate of the previous 5 years, at more than 20 percent under budget for all projects, including design, permitting, mitigation, and construction.

Approximately $350 million was spent on construction in the first year, while $105 million was saved due to innovations and bid packages, representing a 23-percent savings. With 90 percent of construction dollars going directly to local contractors, another $80 million was returned to the community through spending by local contractors during just the first 4 months of construction. That savings was invested in the community at a time when the local economy was depressed, with one of the highest home foreclosure rates in the Nation. In addition, these returns do not include what was paid to the local design community.

A No-Frills Approach To Design

Unlike design-bid-build, CM/GC brings the builder into the design process at a stage where definitive input can have a positive impact on the project. Using a no-frills, bare-bones approach to design plans, CM/GC can rapidly deliver early work packages for a quality project, under budget, while also maximizing the project scope within the available funds.

In addition to speed, another advantage of CM/GC is control. Projects are designed basically around a table, during weekly project meetings with the entire team present, rather than in a design office where the team members have little or no active interaction with each other. One goal of CM/GC is to review the plans during those weekly design/production meetings and produce construction-ready drawings rather than bid sets. There is no need for bid sets, because the owner is not using the low-bid system.

The contractor obtains prices from the preselected subcontractors also working around the design table. Rough order of magnitude estimates become available as designs are discussed. The final pricing simply involves fine-tuning those estimates.

The CM/GC delivery method removes the requirement to have 100-percent signed and sealed drawings to bid the work. Plans need only to be at a level of completion that enables the contract manager to price the work. Moreover, traditional 30-, 60-, and 90-percent reviews are no longer necessary, because the entire team reviews the plans weekly.

CM/GC projects do not need a fully developed design package, as with low-bid projects, or a complex performance specification, as with design-build projects. In addition, CM/GC gives the owner the ability to specify verbally the vision, goals, and objectives for the overall project.

Another Success: Gila River Indian Community

In Arizona, the department of transportation of the Gila River Indian Community needed to replace the existing Sacaton Road (Route 7) Bridge over the Gila River. The bridge needed to be replaced because of frequent over-topping during storms and the need to improve roadway safety. For this project, it was during the design phase, in particular, that CM/GC really paid off.

Initially, the transportation department followed traditional project development practices, but that resulted in a design that the Gila River Indian Community could not afford. Also, the proposed design required an estimated 6-month road closure. The department recognized the need to break the traditional molds and try a new approach.

Once the CM/GC team was formed, the members spent the

Bassel Kassem, SAI Consulting Engineers

This interchange at the John Young Parkway and Osceola Parkway in Florida is one of several projects completed under a CM/GC contract that saved the county time and money.

first weeks reviewing the existing plans and alternative approaches. The team opted for a new design using slide-in bridge construction. In doing so, they reduced the road closure from months to just 9 days. In addition, the design embodied innovation by creating an onsite precast yard, which precast half of the bridge on each side of the crossing and then slid them together. This was the first lateral bridge slide in Arizona.

One of the pillars of this team approach was understanding the importance of thinking through contingencies and allowances. First, the team set aside an allowance for unknowns such as major flooding. The team had reviewed the historical data and were pretty confident that they would not have any major water flows. As it worked out, they did have one small occurrence during construction. Because of the team's prior planning and the willingness of the owner to assume a greater percentage of risk and to include a small allowance, the project stayed on schedule and within budget.

Steven Johnson, senior civil engineer with the Gila River Indian Community DOT, adds, "All in all, I consider the project an incredible success and would highly recommend that other agencies consider this construction methodology. Having the contractor's input during the design phase of the project, which is inherent to the CM/GC process, enabled us to deliver the best product at the lowest possible cost."

Fast Tracking Design And Construction

As noted, CM/GC has the greatest ability to fast-track early components of construction, prior to complete design, in phased packages, resulting in significant time savings. Design is accomplished in priority order by construction needs and budget constraints. CM/GC enables the team to permit the project in small mini-phases, so construction can begin prior to all design being complete and up to 1 year earlier than design-bid-build. Successful implementation also requires that a project be divided into multiple phases to allow for early starts, early product or material procurement, and addressing of right-of-way, permitting, or utility relocation challenges.

Overall, the fast-track nature of this alternative delivery method leads to a short-term need for increased rates of plan production. This places additional requirements on the designers, such as extended work hours, to keep pace with the acceleration and innovation changes proposed by the contractor.

Tallying Up the Price

Tallying up the project price starts by the team looking for a first work package known as a mini-guaranteed maximum price (GMP). Creating this first work package and fast start is a somewhat strategic exercise, as it gives the team an early win and instant momentum. It also serves as a practice run for future mini-GMPs for the project and ultimately the final GMP. The final GMP is the team guaranteeing their upper management that the project will finish within this price, regardless of what happens during design and construction.

Once the first mini-GMP is executed, the second contract phase kicks off and construction begins. Note that the team has no contractual obligation to move forward from the design and pricing phase, often referred to as the preconstruction phase, to the construction phase until the mini-GMP is executed.

CM/GC Success Story: Estes Park

With the use of a CM/GC procurement, a parking lot project at the visitor center in the town of Estes Park in Colorado expanded the original parking count from 102 to 415 spaces. The project's success exceeded the objective of delivering 300 new spaces to encourage hikers and other visitors to park and use the town's shuttles to reach the downtown area and Rocky Mountain National Park.

The $9.8 million project opened for operation on time and under budget. Five entities provided the funding: Town of Estes Park, $5.9 million; Federal Transit Administration, $3.2 million; Colorado Department of Transportation's (CDOT) Funding Advancements for Surface Transportation and Economic Recovery Act of 2009 (FASTER) grant, $400,000; FHWA Congestion Mitigation and Air Quality Improvement grant, $275,000; and Rocky Mountain National Park, $10,000.

The project was the town's first experience using CM/GC procurement. "We had never built a parking garage before, and both the public works staff and town trustees were reluctant to add learning a new procurement method on top of the extra effort required to successfully launch this project type," says Greg Muhonen, the town's director of public works.

"However, after receiving coaching and encouragement from FHWA, coupled with the results of a rigorous comparative evaluation of design-bid-build, design-build, and CM/GC, the town concluded that the use CM/GC procurement

Replacement of the Sacaton Road Bridge, shown here, was procured through a CM/GC contract by the Gila River Indian Community in Arizona. *Photo: Gila River Indian Community.*

Using a CM/GC approach for the first time, the town of Estes Park, CO, was able to design and construct a new parking garage (shown here) at its visitor center in record time.

Town of Estes Park

was the only viable method for moving forward quickly enough to meet the looming expiration of a $400,000 CDOT grant while still maintaining local control of project cost and risk."

Muhonen continues, "During the final design and construction period, we nearly doubled the project size and cost by expanding from a two-level to a four-level structure, but added only 1 month to the construction time. It was essential to the town that this project be operational for the wave of visitors we receive for the July 4th holiday."

He adds, "This CM/GC project rewarded the team with the satisfaction of delivering the new structure on time and under budget. The greatest satisfaction has been listening to the delight and compliments from our town residents, trustees, and guests regarding our new transit facility's parking structure, which opened on July 1, 2017. We are looking forward to seeing corresponding decreases in traffic congestion and improvement in air quality as more of our visiting guests park and ride shuttles into downtown and Rocky Mountain National Park."

Ginny McFarland, project leader with the town, says, "We learned that one of the key elements to success in CM/GC is finding enthusiastic subs who are excited about the CM/GC process and getting them involved early and often in the design process."

She notes that this aspect was highlighted by the timber framer who from the outset embraced the CM/GC process. He valued his role as a design participant and was important to the team effort at finding innovative solutions that improved design, satisfied the owner, and saved the project money. He came in well under budget after several meetings to understand client preferences and eliminate elements that did not speak to satisfying those goals. From material selection to level of craftsmanship to erection methodology, he worked with the owner and contractor to create efficiencies and find solutions to deliver a successful project.

"His work process and final product delivery were a demonstration of the successful collaboration enabled by the CM/GC as a design delivery approach," says McFarland.

A Cultural Change

Notably, a change in design philosophy from traditional design-bid-build projects is necessary to implement a CM/GC program successfully. Early and continuous innovations, right-of-way phasing, real-time pricing, and accelerated design may require additional cultural and educational shifts because of the change in responsibility for managing the project schedule and budget from the owner and designer to the contractor.

In many cases, CM/GC requires a significant and aggressive change in the culture of the owners, contractors, and designers. For instance, the standard design methods, schedules, and plan review stages that are frequently used in designing design-bid-build projects may prove to be inadequate to realize the advantages of CM/GC. Designers are required to take a much more active role in working with the owner and contractor during the entire design process.

Today, ACMs are thoroughly vetted. The transportation industry is now in a prime position to take advantage of the ability of ACMs to work successfully for all project partners. This advantage equates to being free to discuss the means and methods before plans are drawn and design budgets are spent. All in all, ACMs—especially CM/GC—are a win-win for transportation agencies as well as the public.

Victoria J. Peters became director of the Center for Local Aid Support in July 2016. The center provides national leadership in the advancement of innovative technologies, training, and technical assistance for local, tribal, and Federal land management agencies. Prior to this position, she served in multiple positions in FHWA. She holds a bachelor's degree in geological engineering from the South Dakota School of Mines and Technology.

Kenneth E. Atkins, P.E., is a national subject matter expert with the Construction and Project Management Technical Service Team at the FHWA Resource Center. Also, Atkins is an instructor at the University of Florida's Rinker School of Construction Management. He holds a master's degree in civil engineering specializing in construction management from the University of Florida's Department of Civil & Coastal Engineering and a bachelor's degree in engineering from the University of South Florida. Atkins is also a licensed professional engineer in Florida.

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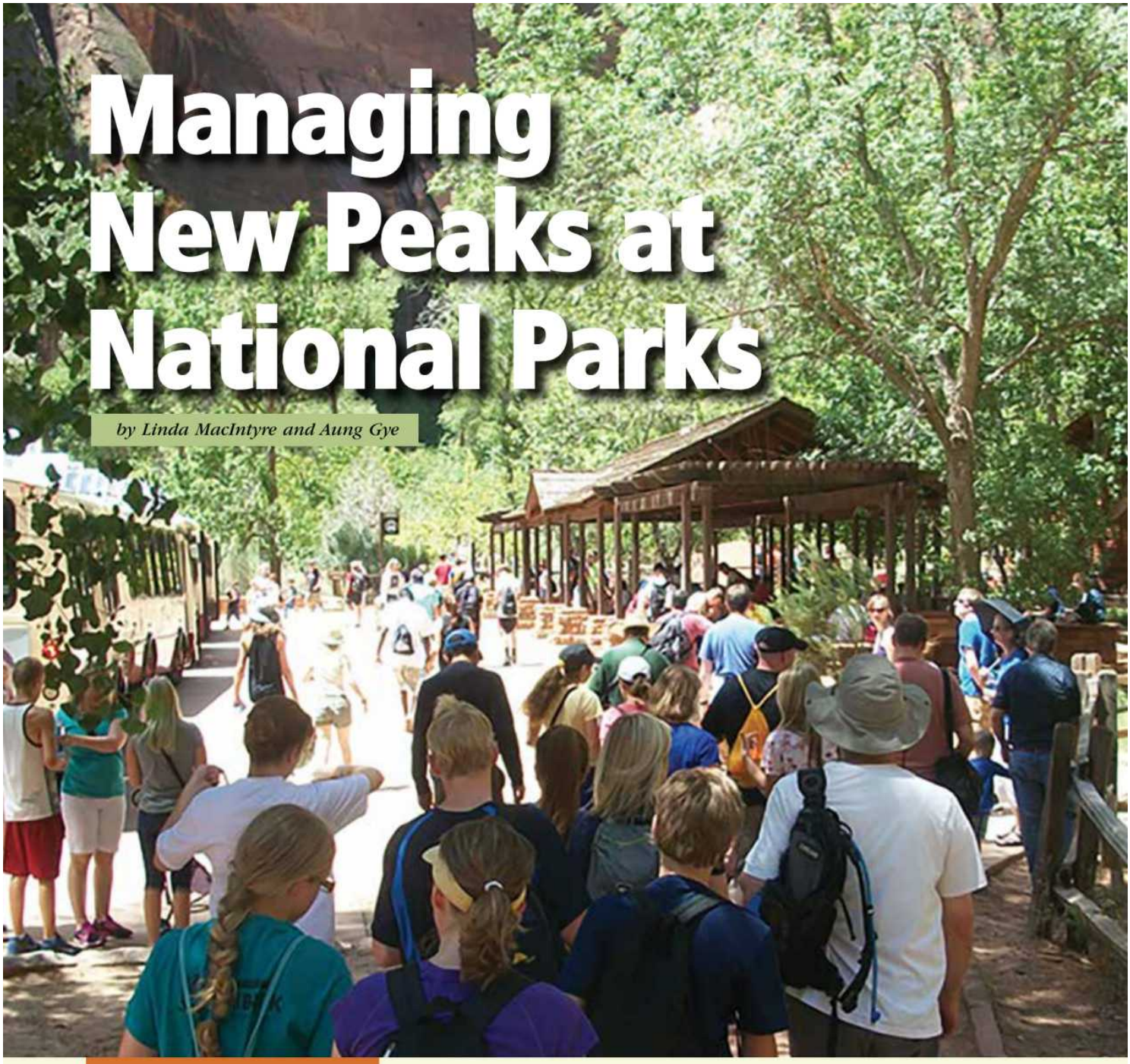


Managing New Peaks at National Parks

by Linda MacIntyre and Aung Gye

Visitors are flocking to the Nation's natural and cultural wonders in record numbers. How are agency leaders responding to the related traffic and impacts? Here is the story of new approaches to managing congestion in a recreational setting.

In 2016, the National Park Service (NPS) celebrated the agency's centennial anniversary. The keystone of the celebration was a nationwide campaign called "Find Your Park." The campaign encouraged members of the public to find and explore national parks throughout the Nation. More than 330 million visitors answered that challenge, resulting in a 21-percent increase in visitation over 2006 levels.

Transportation facilities such as roads, parking lots, and buses are often the gateway experience to national parks for many visitors. For visitors traveling to areas like Washington, DC, traffic congestion may be expected. The Arlington Memorial Bridge (part of the George Washington Memorial Parkway) carries more than 70,000 commuters across the Potomac River each weekday. However, in rural areas or where adjacent to wilderness, delays finding a parking space, time spent in an entrance station queue,

National parks are experiencing a surge of visitors. Here, long lines of visitors stretch from the Zion Canyon Shuttle in Utah's Zion National Park, at the Temple of Sinawava in August 2015. *Photo: NPS.*

or traffic jams on a park entry road may be an unwelcome surprise and diminish a visitor's experience.

In the years leading up to the centennial anniversary year, many parks reported seeing substantial increases in both visitation and related traffic congestion. To maintain access for visitors while protecting resources and preserving safety, NPS is responding to increasing congestion using best practices in traffic management and in social science.

NPS Mission Statement

The National Park Service preserves unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations. The Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

A Systemic Management Issue

Unlike commuter and freight travel patterns, which are well-known and extensively studied, no model exists to predict recreational travel patterns. Levels of traffic may vary greatly from year to year or even week to week, depending on economic factors, regional events, and marketing done by each State (for example, Utah's extremely successful Mighty 5® campaign promoting national parks is likely a factor that influenced recent visitation upticks in Zion and Bryce Canyon National Parks). Managing congestion within this uncertainty requires leadership from park management and expertise from planners and social scientists, along with patience and understanding from visitors and park partners.

In 2010, NPS conducted an agencywide survey to gain a better understanding of why and where park congestion occurs. Of the 188 parks that responded, 59 percent reported that they have (or previously had) congestion. According to the survey responses, the most congested NPS areas are parking lots, roadways providing access to the parks, and visitor centers. The top three congestion-related impacts are decreased visitor experience, reduced safety, and challenges to park operations.

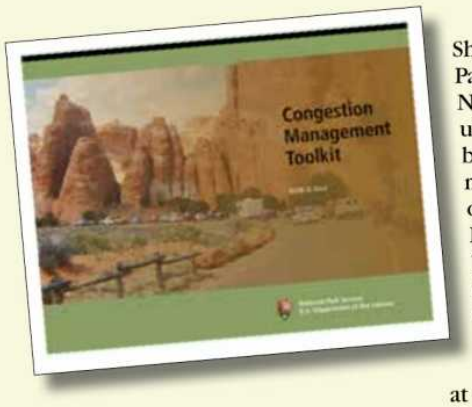
Many parks also reported congestion during morning and evening commuter peaks (for example, commuter routes pass through parks like Saguaro National Park in Arizona and Valley Forge National Historical Park in Pennsylvania) along with midday tourist peaks. Other findings revealed that multiple parks had more congestion on weekdays versus weekends, and that the majority of parks with congestion were in rural areas (rather than those within an easy commute of a large urban area). In short, the 2010 survey revealed that congestion is a challenge at many parks, in many locations, and on more than just summer weekends. Essentially, the survey results revealed that congestion is a systemic management issue for NPS.

Responding to The Challenges

Departments of transportation, cities, and counties use a wide range of well-tested congestion mitigation tools. Many of those tools are adaptable for use in national parks, but others (ramp meters, for example) are not appropriate in a recreational setting because they may impact cultural landscapes or wildlife patterns, or be intrusive to the visitor experience. In the past, NPS often expanded parking lots and launched transit systems to mitigate congestion. While many of these "first generation" systems are very popular with visitors, they have not fully resolved congestion—in fact, shuttles appear to have increased crowding at already-crowded destinations and contributed to parking demand increases at shuttle stops. Improving operations at entrance stations and decreasing wait times often has led to more cars entering the park faster, only to find more cars arriving at parking lots at the same time, creating parking congestion.

"As cities throughout the United States have discovered, NPS cannot build its way out of congestion," says Steve Suder, multimodal program manager with NPS. "Adding new parking lots, entrance station lanes, or new buses to popular destinations sometimes produces a counter-intuitive impact—even more crowding. We believe that improving our traffic operations in the field is essential to reducing congestion."

Because transportation planners and others with related expertise are rare in parks, two new nationwide efforts tailored to support NPS field conditions have emerged: the Congestion Management Program and Visitor Use Management.



Congestion Management Program

NPS maintains a transportation asset management portfolio as part of the Federal Lands Transportation Program. The asset management program at NPS includes congestion management. Because NPS has no systemwide congestion data (and is unlikely to have any in the near future because of the cost of data collection), the NPS Congestion Management Program discarded a systems engineering approach in favor of a programmatic one. The programmatic approach focuses strongly on assistance to the field, rather than on data collection and analysis. Two elements form the backbone of the Congestion Management Program: the *Congestion Management Toolkit* and congestion assessment reports.

Congestion Management Toolkit. In March 2014, NPS published the *Congestion Management Toolkit* custom designed for NPS parks (and easily adaptable for any Federal, State, or local recreation agency). More than 50 tools—from traffic calming and circulation changes to adding shuttles and parking management—offer parks the flexibility to address a tremendous variety of congestion problems. Each tool comes with a general description, information on where to use it, implementation considerations like cost and timeframe, and examples of past deployments of the tool. The toolkit respects current NPS funding and staffing levels, along with partner concerns and visitor access needs.

Parks all over the United States, including Chesapeake and Ohio Canal National Historical Park in the District of Columbia, Maryland, and West Virginia; Cuyahoga Valley National Park in Ohio; Fort McHenry National Monument and Historic Shrine in Maryland; Glacier National Park in Montana; and Joshua Tree National Park in California, have used the toolkit to explore potential beneficial changes in congestion management operations. Outside of NPS, FHWA's Office of Federal Lands Highway, the Volpe National Transportation Systems Center, and numerous consultants have used the toolkit to support transportation planning activities for parks.

The toolkit is available for free at www.nps.gov/transportation/pdfs/NPS-CMS_Toolkit.pdf.

Congestion Assessments. Congestion assessments are a quick response—a triage of sorts—for parks facing congestion management challenges. Launched in 2015, assessments are short standardized reports that blend observations from park staff in the field with transportation expertise. Assessments summarize a park's congestion problems and note past and projected planning efforts and congestion hotspots. The assessment report includes a customized implementation table based on the tools from the *Congestion Management Toolkit*. The entire process is generally completed within 90 days. Assessments can be a standalone product, a prelude to a transportation plan, or an input to other comprehensive visitor use management planning.

As of fall 2017, 12 parks had completed assessments. At least 15 more assessments, including ones at Hawaii Volcanos National Park in Hawaii, Mesa Verde National Park in Colorado, and Sleeping Bear Dunes National Lakeshore in Michigan, are slated for completion in 2018.

Managing Visitor Use

In 2011, six Federal agencies collaborated to charter the Interagency Visitor Use Management Council: the Bureau of Land Management, U.S. Forest Service, National Oceanic and Atmospheric Administration, NPS, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service. The council's goal is to enhance best practices, interagency consistency, cost-effectiveness, and the defensibility of decisions related to visitor use management. In 2016, the council launched a new Federal land management interagency framework to address issues such as visitor crowding, congestion, and related resource impacts that may accompany an increase in visitation or a change in visitor use patterns, or both.

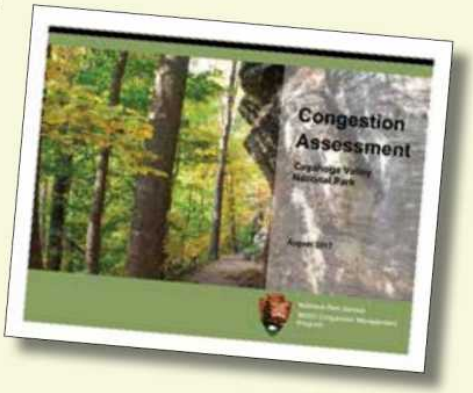
Proactively managing visitor use increases the ability of NPS to protect resources, encourage access, and improve visitor experiences. The four-step framework for managing visitor use stresses flexible goals and implementation using a sliding scale of analysis. The time, money, and other resources spent on planning is calibrated to the complexity of the situation.

The visitor use management methodology helps parks to develop a collaborative vision for providing and managing visitor use in a unit of the National Park Service. The process examines current and potential strategies for providing access, connecting visitors to key experiences, and managing impacts to protect resources and promote high-quality visitor experiences, while meeting legal requirements. More information on visitor use management is available at https://visitorusemanagement.nps.gov.

Responding in the Field

The most common traditional strategies used by NPS to relieve traffic congestion are using rangers to direct traffic, managing special events with volunteers and by reallocating staffing, providing transit with remote parking lots, and changing traffic circulation.

Special events like the Sturgis Motorcycle Rally at Devils Tower National Monument in Wyoming and Patriots' Days at Minute Man National Historical Park in Massachusetts are long-established events where parks actively manage congestion for a short time. While parks can manage traffic related to planned special

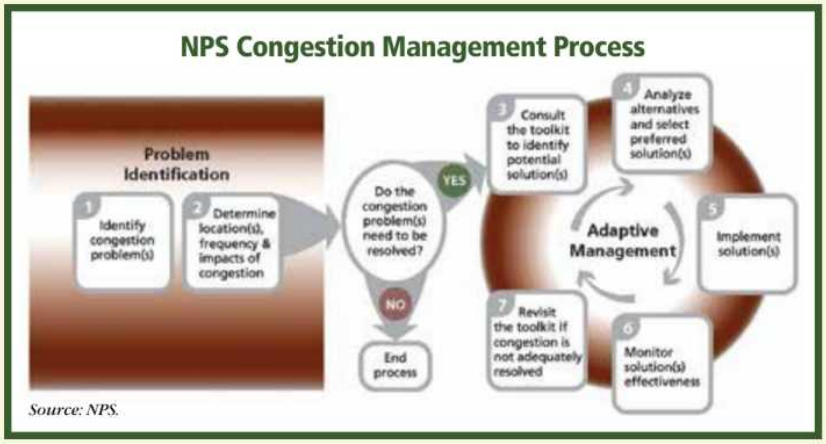


events, managing traffic at high levels every day is not sustainable because of staffing and budget constraints, and potential negative impacts to visitor experience and natural resources.

Sometimes intensified crowding may mean that some restrictions on access or parking become necessary to preserve resources and provide an outstanding visitor experience. Parks actively considering a reservation system include Acadia National Park in Maine, Arches National Park in Utah, Glacier National Park in Montana, Muir Woods National Monument (part of Golden Gate National Recreation Area) in California, and Zion National Park in Utah. Except for Arches, all of these parks already have a transit system in place.

In July 2017, visitation levels in Glacier National Park topped 1 million for the first time (a 100-percent increase over 2000 levels). The park's superintendent, Jeff Mow, offered a friendly reminder about conditions in the park during the unprecedented influx of visitors. "We ask that visitors bring their patience, prepare for significant parking delays, and expect more people on the trails this summer," he said. "Glacier Country has a tremendous amount to offer its tourists. While people wait for times that are less crowded to visit the park, our surrounding public lands and local businesses can offer exceptional opportunities for people coming to see this spectacular region."

More parks also are beginning to experiment with an adaptive management framework for traffic operations to reduce congestion, rather than building new facilities. In 2016, rangers at Yellowstone National Park's West Yellowstone entrance station in Montana restaged their staff to reduce long lines of vehicles, which at times had stretched into the community. Rangers walked the queue to greet visitors before they got to the fee booth. They offered welcoming messages, a park newspaper, and other information, resulting in dramatically reduced queues.



Source: NPS.

In another example, Great Sand Dunes National Park and Preserve in Colorado completed a congestion assessment in 2017 that focused on operational strategies to manage crowds. The park's approach included making minor changes in entrance station operations, establishing temporary dropoff zones, assigning rangers to control traffic, and opening temporary parking areas. This approach proved successful throughout the peak visitor season.

Swelling Crowds at Zion National Park

Zion National Park is an example of a rural national park experiencing dramatic visitation increases along with crowding and resource impacts. In 1997, Zion limited personal vehicles in most of Zion Canyon and launched a transit system to address growing visitation. For a time, transit successfully restored quiet to the canyon, and visitors enjoyed the opportunity to leave their vehicles behind. The system enabled them to "hop on/hop off" for easy access to trailheads, water, and geology. Today, with dramatic increases in visitation that the shuttle alone cannot address, Zion Canyon is once again a crowded and noisy destination.

In summer 2017, visitation at Zion was double what it was when the transit system launched. Long lines for buses, packed conditions on steep trails, and safety impacts are all concerns for park management.

"Visitation at Zion National Park is skyrocketing at a rate exceeding even recent record-setting years," says Jeff Bradybaugh, superintendent of Zion National Park. "Over Memorial Day weekend, our busiest weekend, we hosted well over 90,000 visitors. The incredible increase in crowd size supports the need for developing a plan to proactively manage visitation levels to protect park resources and provide the exemplary experiences visitors expect in their national park."

Zion's park management team is considering three preliminary alternatives to reduce congestion and improve visitor use management. In addition to a no-action option, two action alternatives propose versions of a reservation system. One alternative is an online, year-round reservation system for all front-country areas such as Zion Canyon. The other alternative proposes a reservation system only for specific sites such as heavily used trails and other crowded areas.


These visitors experienced crowded trail conditions on Angels Landing in Utah's Zion National Park in June 2017. *Photo: NPS.*

In Ohio's Cuyahoga Valley National Park, an overflow of cars had to park along the roadside outside the Brandywine Falls parking area on Memorial Day 2017. *Photo: NPS.*

Prior to selecting the three preliminary alternatives, the park considered a wide variety of management strategies. It dismissed items such as implementing congestion pricing, adding new and expanded parking, dispersing use to other areas of the park (more than 90 percent of the park is wilderness), and adding more shuttle buses (because it could not add or financially support enough shuttles to meet the growing demand). Zion expects to select a preferred alternative for its plan in 2018.

Congestion at Cuyahoga Valley

Cuyahoga Valley National Park is located between Cleveland and Akron along the Cuyahoga River in Ohio. Congestion is on the rise in Cuyahoga Valley because of shifts in visitor activities (growing interest in cycling, hiking, and river-related activities) and modest increases in overall visitation. Like many parks, most visitors arrive in a personal vehicle. A unique feature of this park is the Cuyahoga Valley Scenic Railroad, which features a hop-on/hop-off rail service to and from Cleveland.

The park's boundaries are porous, meaning it has no entrance stations, and it includes many attractions and related parking areas. Dozens of partners own, operate, and maintain the roadways that crisscross the park. Because the park does not own any of the roadways, staff is somewhat limited in its management options. The efforts at Cuyahoga Valley have focused on parking management and improving distribution of special events throughout the park.

Most visitors are local, repeat visitors. In the past, picnics and family events were very popular in the southeast portion of the park. Recently, the park has experienced a significant shift toward the use of two regional bike trails, a greater number of train riders, and increased interest in river kayaking. These shifts mean that visitors are now largely concentrated in the park's central river/trail "spine," resulting in a substantial increase in parking congestion near these facilities. At times, parked cars may stretch along roadsides for more than half a mile (0.8 kilometers) from a popular trailhead, while large parking areas previously frequented by families are underused.

In summer 2017, staff from Cuyahoga Valley National Park, NPS' Denver Service Center, and the Volpe National Transportation Systems Center participated in a congestion assessment, designed to expand the park's March 2017 parking management approach. In less than 90 days, the team developed the assessment with multiple tools for the park to adapt to changing conditions, including improved special event coordination and better circulation in crowded parking lots. The assessment plan has a strong emphasis on flexibility to address parking, safety (particularly at crowded railroad crossings), visitor information, and issues related to special event management.

"With significant congestion at several of our more popular areas, and due to concerns for visitor safety, resource integrity, and to improve visitor experience, we were excited for the opportunity to work with the Congestion Management Program," says Craig Kenkel, superintendent of Cuyahoga Valley National Park. "We readily welcomed the assessment and the process was straightforward and very beneficial. The team is professional, [and they] provided ideas and solutions, and validated work we have already implemented."

What's Next?

As visitation levels rise, parks must carefully consider when and how to intervene to protect resources, visitor experiences, and safety from traffic-related impacts. New tools, advances in social science methods, and faster options for delivering technical support are helping parks to respond to traffic congestion within an adaptive management framework.

With support from transportation and visitor use management specialists, parks will remain dedicated to providing enjoyable and memorable access for the visitors of today, while preserving world-class resources and experiences for the visitors of tomorrow.

Linda MacIntyre serves as the manager of NPS' Congestion Management Program, which is part of the Federal Lands Transportation Program. She has over 25 years of experience in transportation planning, strategic planning, and public lands management. MacIntyre has a bachelor of arts degree in political science and a master's degree in urban and regional planning, both from the University of Colorado.

Aung Gye is the Transportation Planning team leader in the Office of Federal Lands Highway at FHWA in Washington, DC. He manages the Transportation Planning Program within FHWA's Office of Federal Lands Highway.

For more information, contact Linda MacIntyre at 303-969-2483 or linda_macintyre@nps.gov.

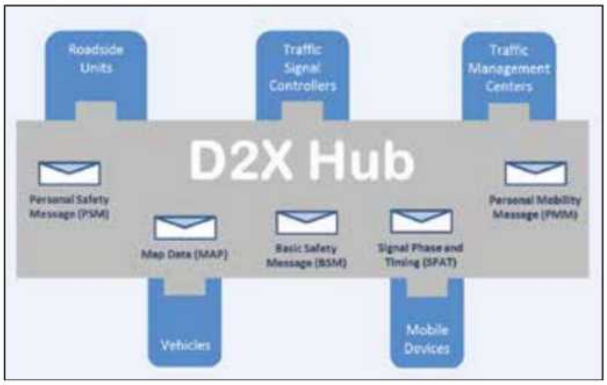
Along the Road

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.

Technical News

USDOT Completes D2X Hub Field Test

Researchers in FHWA's Office of Operations Research and Development are developing the Mobile Device-to-Everything (D2X) software platform, called the D2X Hub, to enable mobile devices to share data in the formats unique to connected vehicles, roadside infrastructure using intelligent transportation systems (ITS) technology, and other travelers using mobile devices. In June 2017, researchers conducted a prototype field test in Columbus, OH, to evaluate the feasibility of sharing data with connected mobile devices and the hub's ability to support the translation of these messages to be used by connected vehicles and ITS devices.



The D2X Hub enables the exchange and use of messages between connected devices, vehicles, and ITS infrastructure. *Source: USDOT.*

The D2X Hub translates, aggregates, and coordinates the exchange of data using software applications within its platform. These applications must be installed on each connected mobile device, vehicle, ITS and traffic control device, or traffic management system. Through the field test, FHWA demonstrated D2X Hub capabilities to assess mobile devices sending and receiving messages using different communication mediums (such as Wi-Fi, cellular, or Bluetooth®) with traffic management systems, transit vehicles, and connected vehicles.

Funded by the USDOT ITS Joint Program Office, the D2X Hub will provide public agencies with a platform to facilitate the exchange of data to improve how they provide transit services and manage traffic and the safety and mobility of travelers using connected mobile devices. The D2X Hub prototype and supporting documents are available to download at www.itsforge.net/index.php/community/explore-applications#/45/135.

For more information, contact Jon Obenberger at 202-493-3265 or jon.obenberger@dot.gov.

TxDOT Uses New Technology for Flood Relief

After Hurricane Harvey made landfall on August 25, 2017, and devastated cities along the Texas coastline, the Texas Department of Transportation (TxDOT) quickly moved to mitigate extreme flooding. As the storm moved north toward Houston and Beaumont and with waters rising, TxDOT crews from several area districts received and deployed an innovative technology called AquaDam, which enabled the delivery of aid to victims who otherwise would have been cut off because of flooding.

TxDOT

Crews install an AquaDam barrier on flooded Texas roads after Hurricane Harvey in summer 2017.

AquaDam is a large mobile dam that can be installed to block off up to 30 inches (76 centimeters) of floodwater, either rising or already in place. A water-filled tube uses existing floodwater to create a barrier, effectively taking the problem and turning it into a solution. The installation during Hurricane Harvey was TxDOT's first use of the technology.

"If the water is stagnant, you can install the AquaDam with a crew of 12," says Cory Taylor, the director of maintenance for TxDOT's Beaumont District. "If the water is moving, installation can be more challenging and require as many as 40 crew members."

Purchased from Louisiana, the AquaDam equipment was delivered directly to five sites for immediate use and proved to be highly effective. Installation time ranged from 4 to 8 hours, depending on conditions at each location. One of the installations—measuring just under 1 mile (1.6 kilometers) long—opened up approximately 15 miles (24 kilometers) of I-10. TxDOT plans to continue using the technology in the future.

For more information, contact TxDOT Media Relations at mediarelations@txdot.gov or 512-463-8700.

TxDOT

MDOT Improves Work Zone Visibility

After a successful test of wet reflective paints for use in work zones, in June 2016, the Michigan Department of Transportation (MDOT) mandated the use of temporary wet reflective tape and paint in work zones, which went into full effect in 2017. The requirement is the first of its kind in the United States.

In 2015, MDOT teamed up with a local contractor to test and create wet reflective paints for performance in dark, wet work zones to improve nighttime visibility, particularly in rainy conditions. The developed products proved so effective that MDOT set new guidelines and standards for work zones throughout the State. The temporary paint is designed to hold wet reflective optics for a 2-month work zone.

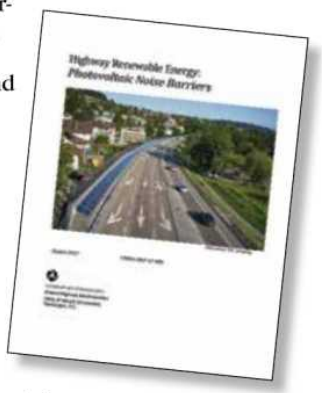
"We're always trying to innovate and we are motivated by safety," says Chris Brookes, a work zone delivery engineer with MDOT. "Thirty-five percent of work zone crashes happen on rainy nights and we believe this new standard will make a big difference."

MDOT

Public Information and Information Exchange

FHWA Releases Report on Photovoltaic Noise Barriers

In August 2017, FHWA released *Highway Renewable Energy: Photovoltaic Noise Barriers* (FHWA-HEP-17-088). The report describes the experience of using photovoltaic noise barriers to lessen the impact of noise while producing renewable energy. Photovoltaic noise barriers represent the combination of noise barrier systems and photovoltaic systems. Photovoltaic systems use solar cells to convert light energy directly into electricity. The report explores pilots underway by State transportation agencies, the business case for photovoltaic barriers, and the potential for solar energy production on U.S. noise barriers.



First deployed in Switzerland in 1989, photovoltaic noise barriers are now found in several countries where transportation agencies have looked for multiple uses for their infrastructure. The experience of these countries, documented in literature and supplemented through a series of interviews by the report's authors, provides evidence that noise barriers can be designed to produce renewable energy without compromising the safety or ability to reduce noise.

Researchers estimate that, given the substantial use of noise barriers in the United States, the potential for solar energy production from photovoltaic barriers is likely at least 400 gigawatt hours annually. That amount is roughly equivalent to the annual electricity use of 37,000 homes.

The business case for these barriers often hinges on the availability of subsidies or other incentives that promote the renewable energy market. Although no U.S. transportation agencies have built photovoltaic barriers to date, at least two State departments of transportation are currently working with partners to pursue pilot projects.

For more information, visit www.fhwa.dot.gov/environment/sustainability/energy/publications/photovoltaic/fhwahep17088.pdf.

SCDOT Launches 10-Year Plan and Web Site

The South Carolina Department of Transportation (SCDOT) has mapped out a decade-long plan designed to rebuild decayed roads and replace structurally deficient bridges across the State. With the passage of the State's Roads Bill, which went into effect July 1, 2017, the agency has an increased and sustainable revenue stream to enable consistent improvement.

The Roads Bill implemented the first increase of the State's gas tax since 1987, with 2 cents added in July 2017 and an additional 2 cents per year for a total of 12 cents at the end of a 6-year period. The bill also raised the vehicle sales tax and other vehicle-related fees.

The State's 10-year plan includes projects to improve highway safety, structurally deficient bridges, interstate widening, and road resurfacing. South Carolina has the highest fatality rate on rural roads in the Nation. SCDOT will address the "worst-of-the-worst" roads by improving 100 miles (160 kilometers) per year with a customized plan to make the roads safer in 10-mile (16-kilometer) segments.

The agency also will replace more than half of its 750 structurally deficient bridges, begin 11 or 12 interstate widening projects, and use 50 percent of the new revenue to resurface State highways. About 80 percent of the 42,000 miles (68,000 kilometers) of State-maintained highways need resurfacing or rebuilding. The 10-year goal is to bring half of those roads up to a "good" rating.

SCDOT will make periodic reports on the progress of the 10-year plan as revenue accumulates and projects move forward to construction. To help keep the public informed of its progress, the agency launched a Web site for the 10-year plan at www.scdot.org/tenyearplan. The site lists all projects statewide as well as broken out into four regions. The site also includes a link to SCDOT's interactive Project Viewer, which provides a more detailed look at in-progress projects.

SCDOT

NHTSA Releases Report on Marijuana-Impaired Driving

The U.S. National Highway Traffic Safety Administration recently released a report to Congress that explores the effects of driving while using marijuana. *Marijuana-Impaired Driving: A Report to Congress* (DOT HS 812 440) was prepared in accordance with the Fixing America's Surface Transportation (FAST) Act, and presents

NHTSA's report on marijuana-impaired driving includes a review of relevant State laws.

information on training for law enforcement to detect marijuana impairment in drivers.

The report describes the absorption, distribution, and elimination of delta-9-tetrahydrocannabinal (THC), the primary psychoactive substance in marijuana, in the body. Researchers contrast this process with the absorption, distribution, and elimination of alcohol in the body, as they are very different processes.

The report also discusses the poor correlation of THC concentrations in the blood with impairment and the corresponding implications for setting limits. It reviews some of the challenges of measuring driving impairment resulting from marijuana use and presents State laws relating to marijuana and driving, as well as what is known about the prevalence of marijuana-impaired driving and the associated crash risks.

In addition, the report discusses the feasibility of developing an impairment standard for driving under the influence of marijuana and recommendations for increasing data collection regarding the prevalence and effects of marijuana-impaired driving.

For more information, visit www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/812440-marijuana-impaired-driving-report-to-congress.pdf.

NHTSA

NDDOT Opens New Lewis and Clark Bridge

The North Dakota Department of Transportation (NDDOT) recently opened the single largest infrastructure project bid in NDDOT history: the new Lewis and Clark Bridge located on U.S. 85 south of Williston. The project is part of the U.S. 85 four-lane expansion, which included more than $340 million of State money invested into the bridge, two bypasses, and 60 miles (97 kilometers) of highway between Watford City and Williston.

The $80 million bridge project included construction, engineering, and design of a new four-lane bridge, replacing the former two-lane bridge originally built in 1973. Other parts of the project included bridge lighting, rebuilding the roadway leading up to the bridge, and the construction of a wildlife crossing specifically designed for moose located south of the bridge. This specific kind of wildlife crossing is a first for North Dakota.

The new Lewis and Clark Bridge is a steel girder design with four 12-foot (3.6-meter) driving lanes divided by a center median. The new bridge will accommodate larger, wider truck loads than the old bridge.

Currently, the bridge is open to two lanes of traffic. Contractors are continuing to dismantle and remove the old bridge and complete the final elements of the project. The Lewis and Clark Bridge will be open to four lanes of traffic once all work is complete.

NDDOT

ADOT Partners with Tribes on Construction Academy

In September 2017, members of the Pascua Yaqui Tribe of Arizona earned their certification to work as flaggers on tribal construction projects through a free Construction Academy sponsored by the Arizona Department of Transportation (ADOT).

ADOT

Members of the Pascua Yaqui Tribe attend ADOT's Construction Academy to earn certification as flaggers and laborers for transportation projects.

After completing a series of weekend courses, 27 participants in the Pascua Yaqui Reservation Tribal Employment Rights Organization Construction Academy are qualified to work on road projects on the reservation, located in the southwest Tucson area. Fifteen participants will serve as flaggers for 6 months on road projects administered by the Tribal Employment Rights Organization, while the remaining 12 will work as general laborers. After 6 months, participants will switch roles.

The Construction Academy is a pre-apprenticeship training program offered through ADOT's On-the-Job Training/Supportive Services Program, part of the agency's Business Engagement and Compliance Office.

All Construction Academy programs are designed to remove barriers to construction careers for women and minority individuals and to help participants move on to construction apprenticeships and eventually reach journeyman status, with ADOT continuing to provide support and guidance.

Flagger certification is just one of the training opportunities available to women, minorities, and members of economically disadvantaged groups, including those who are out of work, through these ADOT programs. Individuals also can receive training that will help them become concrete finishers, block masons, highway surveyors, heavy equipment operators, and commercial drivers. ADOT covers training costs and fees for participants and provides support including transportation and child care assistance, job-readiness training, and safety gear such as hard hats and protective eyewear.

For more information, visit https://azdot.gov/BECO or call 602-712-7761.

ADOT

Personnel

Trentacoste Receives Distinguished Service Award

In recognition of his outstanding service to the Transportation Research Board (TRB) and to transportation research, Michael F. Trentacoste received the 2017 W.N. Carey, Jr., Distinguished Service Award. Trentacoste retired as FHWA's Associate Administrator for Research, Development, and Technology on September 30, 2017. The Carey Award—named in honor of W. N. Carey, Jr., TRB's Executive Director from 1967 to 1980—recognizes individuals who have given leadership and distinguished service to TRB.

Trentacoste served as member and then chair of TRB's Standing Committee on Transportation Safety Management. He was the Federal liaison to the Second Strategic Highway Research Program (SHRP2) Technical Coordinating Committee for Safety Research that helped oversee SHRP2's Naturalistic Driving Study, which resulted in the largest collection of data on driving behavior. In addition, Trentacoste was a key player in development of the strategies designed to ensure that SHRP2's research results are implemented. Trentacoste also was a member of and Federal liaison to nine other committees, panels, and task forces.

A frequent contributor to TRB's Executive Committee, Trentacoste used his more than 40 years of service to the transportation community, including 31 years with FHWA, to help TRB fulfill its mission and sustain the vitality of its programs.

As Associate Administrator for Research, Development and Technology, Trentacoste was responsible for leading a comprehensive national research, development, and technology program designed to meet the needs and goals of the highway community and the Nation's highway transportation system. He also served as the director of FHWA's Turner-Fairbank Highway Research Center.

TRB

Internet Watch

by Carrie Boris

Choosing an Asphalt Binder? Look Online

Determining an appropriate asphalt binder is a critical step in selecting materials for paving projects. A binder's properties should be related to the conditions under which it is used, including air and pavement temperatures and traffic conditions at the specific site.

To help highway agencies select appropriate binders for their roadway projects, researchers from the Strategic Highway Research Program developed a system of binder performance grades, called Superpave™, in the early 1990s. Initially, the performance grade specifications were based on lowest and highest temperatures *expected* at a site. Later, the Federal Highway Administration's Long-Term Pavement Performance (LTPP) program improved the temperature models using collected seasonal data of *actual* temperatures.

In 1999, the LTPP program launched its LTPPBind software to make it easier for transportation agencies to apply the methodology and make informed selections. FHWA has updated the software over the years, and the current version is LTPPBind 3.0/3.1. Previous versions of the software required users to download it to a desktop computer to use it—until recently.

In March 2017, the LTPP program launched LTPPBind Online, a Web-based tool to help highway agencies select the most suitable binder performance grades for asphalt pavement at a particular site. It uses standards from the American Association of State Highway and Transportation Officials (AASHTO), AASHTO M320-10 and AASHTO M332-14, as well as the same algorithms as the LTPPBind 3.0/3.1 software for calculating the high and low temperatures. The tool provides pavement engineers with the ability to select binder grades that are less restrictive and more cost effective.

How It Works

LTPPBind Online offers users a choice of climatic data from the National Aeronautics and Space Administration's Modern-Era Retrospective Analysis for Research and Applications (MERRA) dataset, LTPP climatic data (from virtual or automated weather stations), or manually entered data. Using the selected climatic data source and other data entered by the user, LTPPBind Online selects binder performance grades based on actual temperature conditions at the project site and the level of risk designated by the highway agency, and will adjust the selection for traffic volume and speed.

Once a user has selected between MERRA or LTPP climatic data from a map or drop-down menu, or manually entered climatic data, the tool enables the user to input additional data including maximum allowable rut depth, depth of pavement layer, traffic volume, and traffic speed. The tool then produces a selection report, which users can save or print for future reference. The report provides all the parameters used to select a performance grade for the desired location, shows the adjusted performance grade for traffic volume and speed, and provides the high and low performance grades at the 50- and 98-percent reliability levels. The reliability level represents the probability that the pavement temperatures will not exceed the design temperatures in a given year. Furthermore, LTPPBind Online enables users to compare selected binder performance grades between AASHTO M320-10 and AASHTO M332-14.

Improved Accessibility

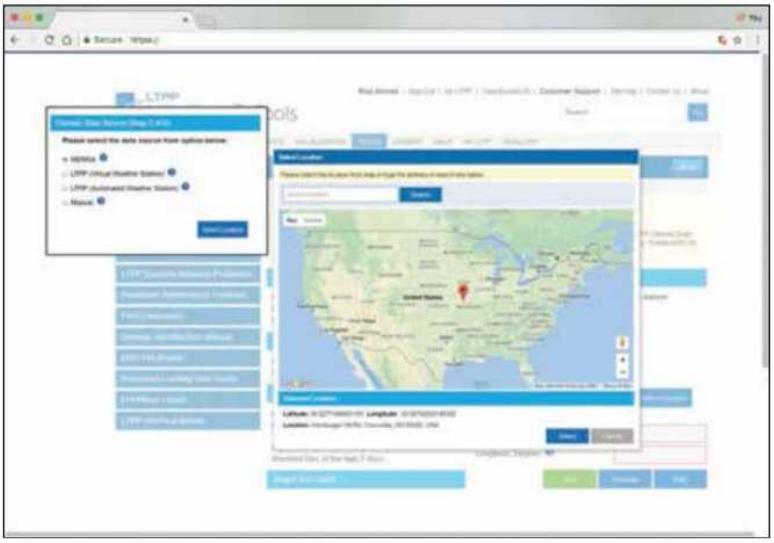
With this Web-based tool, users are not required to install any machine-specific software. However, they do need to register, at no cost, on the LTPP InfoPave™ Web portal at https://infopave.fhwa.dot.gov. To access the binder tool from the portal, users click on the "Tools" tab and select LTPPBind Online.

A complete user's guide (FHWA-HRT-17-010) is available, and users may also submit questions using the customer support feature under the "Help" tab of the LTPP InfoPave portal.

LTPPBind Online can benefit a variety of users, including State and local transportation departments, the highway construction industry, asphalt binder producers, university faculty and students, and highway researchers.

For more information, contact Larry Wiser at larry.wiser@dot.gov or 202-493-3079.

Carrie Boris is a contributing editor for PUBLIC ROADS.



The LTPPBind Online tool enables users to select from a variety of sources for climatic data at a location, or enter data manually.

NATIONAL HIGHWAY INSTITUTE

Training Update

by Fleming El-Amin

Advancing Environmental Justice

Historically, minority and low-income communities have not been engaged meaningfully in the decision-making process for major transportation projects and other infrastructure throughout the Nation. Ensuring full and fair participation by all communities who may be potentially impacted by Federal activities early in the process can help accelerate project delivery. To help address these concerns, in 1994, the White House issued Executive Order 12898 to ensure that Federal agencies make achieving environmental justice (EJ) part of their mission. Agencies accomplish this by identifying and addressing disproportionately high and adverse human health or environmental effects of Federal programs, policies, and activities on minority populations and low-income populations.

As applied to transportation, EJ helps to ensure specific analysis of decisions and meaningful involvement of all communities potentially affected by transportation projects. When EJ is effectively addressed, the development, construction, operation, and maintenance of transportation projects lead to an equitable distribution of benefits and burdens throughout the transportation network.

The Federal Highway Administration addresses EJ through numerous policies, programs, and activities that help to identify and prevent discriminatory effects. These efforts also help ensure that potential impacts to communities and people are recognized early and continually throughout the transportation decision-making process, from early planning through implementation.

To help transportation professionals effectively integrate the principles of EJ and nondiscrimination into all Federal programs and activities, the National Highway Institute (NHI) developed Fundamentals of Environmental Justice.

EJ Training in a New Format

NHI currently offers the EJ fundamentals course in two formats. In summer 2017, NHI launched a 4-hour, Web-based training version, course number 142074. The training explains how EJ applies to each stage of transportation decision making. The course presents participants with a variety of strategies and resources for considering EJ throughout the process.

The Web-based course is available to transportation practitioners at no cost and is strongly recommended as a prerequisite to course number 142005, NEPA and the Transportation Decisionmaking Process, and course 142036, Public Involvement in the Transportation Decisionmaking Process.

The online course includes updates to the resources, guidance, policies, and case studies provided in the 2-day instructor-led version of the training, course number 142042. "The Web-based training allows participants to work at their own pace to gain knowledge on EJ and transportation decision making," says Keith Moore, an environmental program specialist with FHWA's Resource Center and one of NHI's instructors. "However, the in-person, instructor-led version of the fundaments of EJ course provides participants with an opportunity for interagency and cross-agency discussion and networking."

The instructor-led version is still available, although NHI anticipates it will no longer be offered after fall 2018. The course costs $700 per participant and provides 1.2 continuing education units for those who successfully complete the training.

FHWA and NHI are developing a new intermediate-level, 2-day instructor-led training on environmental justice analysis. Once the analysis course has launched, NHI's existing instructor-led Fundamentals of Environmental Justice course will no longer be offered.

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

Fleming El-Amin is a community planner with FHWA's Office of Human Environment.

Stantec

The Newtown Pike Extension in Kentucky involved construction of affordable housing and noise barriers, as shown here, to reduce the impacts on surrounding minority and low-income residential areas.

Communication Product Updates

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

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

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

National Technical Information Service
5301 Shawnee Road
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Addressing Challenges and Return on Investment (ROI) for Paperless Project Delivery (e-Construction) (TechBrief)
Publication Number: FHWA-HRT-16-068

This TechBrief summarizes a program case study that highlights the transformation and automation of the Pennsylvania Department of Transportation (PennDOT) construction process through the development of advanced mobile applications and automated workflows. It also showcases PennDOT's integration of these elements with collaboration tools and payment systems to improve overall efficiency. PennDOT anticipates significant monetary benefits from operational and time-saving efficiencies achieved through implementation of its e-Construction practices.

This TechBrief provides an overview of e-Construction as a national practice, summarizes PennDOT's history and approach to technology implementation, and describes the investment and benefits realized during a 3-year period. This publication aligns with FHWA's research project Addressing Challenges and Return on Investment (ROI) for Paperless Project Delivery (e-Construction), which assesses how transportation agencies are transitioning to a more electronic/paperless project delivery system and documents the costs, benefits, and challenges during the transition.

PennDOT is considered a national leader in e-Construction, having made significant strides in transforming and automating the construction administration process, which eliminates the paper-based environment. However, the real value realized from e-Construction is the significant gain in process efficiencies. This TechBrief provides an overview of PennDOT's processes for electronic submittals of all contract documents for the entire project construction phase using mobile technology to streamline and expedite contract inspection and administration.

The document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/pavements/16068/index.cfm.

FHWA Research and Technology Evaluation: National Household Travel Survey Program Final Report (Report)
Publication Number: FHWA-HRT-16-082

This report examines outcomes associated with the National Household Travel Survey (NHTS) program, namely the extent of NHTS survey usage; the impact of the NHTS program on policy, project, and regulatory decision making; and the responsiveness of the NHTS program to its user community.

It is difficult to trace the specific impacts of the NHTS data, however, the evaluation found many examples demonstrating that NHTS data inform a range of policy and legislative decisions, both within

transportation and in other fields (such as health and energy). In some cases, NHTS provides context and understanding for how, when, and why Americans travel, as well as trends in travel. This context helps make the case for particular policy or legislative initiatives.

In other cases, NHTS is an important data source for a model or statistical analysis, which is used, in turn, to influence policy or legislation. At the State and local levels, NHTS may impact developing, calibrating, or validating travel demand models, which planners use to inform transportation planning and project selection.

The report, which also identifies challenges and lessons learned regarding survey planning, survey administration, and outreach, offers a set of recommendations to improve program effectiveness. FHWA staff, the NHTS user community, and transportation professionals involved in travel behavior modeling, survey research, and evaluation may find the report of interest.

The report is available to download at www.fhwa.dot.gov/publications/research/randt/evaluations/16082/index.cfm.

Hardware in the Loop (HIL) Testing of Connected and Automated Vehicle (CAV) Applications (Fact Sheet)
Publication Number: FHWA-HRT-17-032

FHWA has led the research and development of innovative applications of connected automation that offer the potential for significant benefits for mobility, safety, and the environment. One of the major challenges in testing and demonstrating the benefits of these innovative technologies is the small number of test vehicles available for experiments. This leads to a lack of field data on connected and automated vehicle (CAV) technologies for the development of valid CAV modeling tools for State and local transportation agencies.

One approach to overcoming these challenges is to use emerging hardware in the loop (HIL) tools. HIL tools enable real test vehicles to interact with virtual vehicles from traffic simulators, providing an evaluation environment that replicates actual deployment conditions at early stages of CAV development.

In late 2016, FHWA kicked off an effort to conduct HIL testing of signalized intersection approach and departure (SIAD) and cooperative adaptive cruise control (CACC). This effort will continue to assess the potential impacts of CAV applications—specifically SIAD and CACC—using emerging HIL tools and conduct closed field tests at FHWA's Turner-Fairbank Highway Research Center as well as outside facilities. The project also will develop microsimulation models and model logic to accurately emulate CAV hardware and performance based on the HIL tests and analysis.

FHWA will release additional information on the results of the HIL field tests and model development as the project progresses. Final research results will be available in early 2019.

This fact sheet is available to download at www.fhwa.dot.gov/publications/research/operations/17032/index.cfm.

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