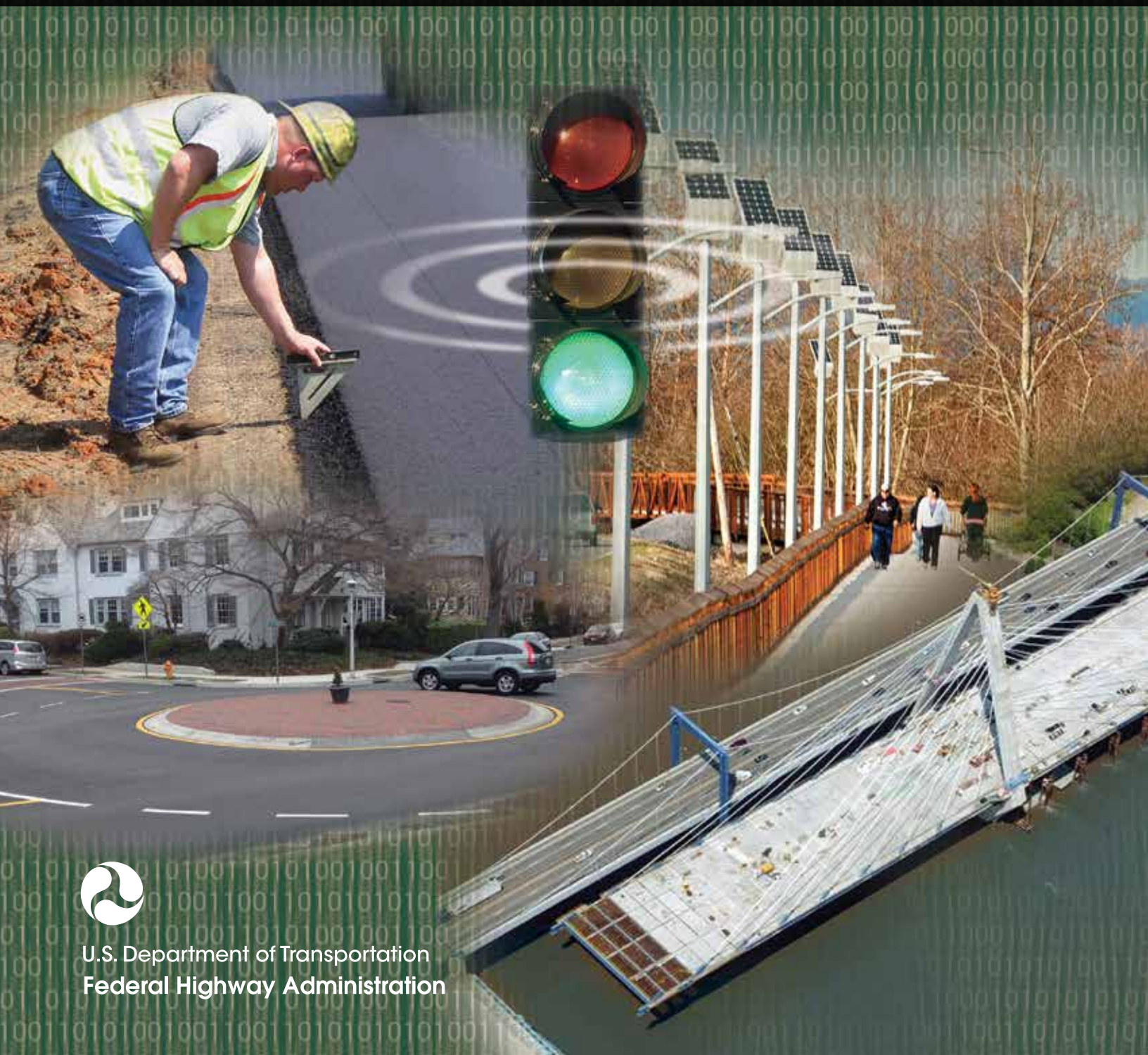
The FHWA 2015

R&T Story

Research and Innovative Solutions for the Nation's Highway Challenges



U.S. Department of Transportation
Federal Highway Administration

A century ago, research and technology (R&T) played a primary role and led to the conversion of unpaved to paved roads with asphalt and concrete pavement materials, an innovation that led to greater and safer mobility on our Nation's highways.

The value of research is seen in the development of large and small innovations in materials, designs, policies, operations, and safety on the highway system. Deployment of those innovations enables the highway system to move people and freight efficiently and contributes to the economic success of the United States (U.S.). Today, as in the past, researchers and inventors continue to develop innovations and solutions to transportation challenges.

The Federal Highway Administration (FHWA) plays a key role in leading the national transportation research needed to meet the challenges now and in the future. Collaborating with partners around the world, FHWA research conducted at its Turner-Fairbank Highway Research Center (TFHRC) is improving the roads and bridges we travel on every day, saving lives, reducing congestion, and advancing economic growth.

From connected vehicles and vehicle-to-infrastructure communications to road and bridge design, to policy decisions requiring quality transportation data, to human factors and environmentally sustainable roads, this is a time of boundless opportunity. What was once dreamed of as the highway of the future is becoming our reality today. And today we are moving toward solutions that will positively impact the transportation system of tomorrow. In the many innovations described here, learn how FHWA's R&T initiatives are contributing to advancements in the transportation system.

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Table of Contents

Construction of detour bridges at this location was impossible since these bridges were only a short distance (50 to 70 feet) from either end of the Elk Creek Tunnel in Oregon. With these severe limitations, the only viable alternative available was to remove and replace the bridges using hydraulic sliding system (HSS), an innovative rapid bridge replacement technique. (Image source: FHWA)

Telling the FHWA R&T Story

Introduction

The U.S. has built one of the world's greatest transportation systems. With more than 600,000 bridges and 8.5 million lane miles, the system is large, complex, and aging.[1]

The U.S. highway transportation system is called the backbone of America because the Nation's economic future depends on its ability to efficiently and safely move people and goods across the country.

U.S. transportation agencies are challenged to make the system more efficient using existing infrastructure and funding resources, while improving travel times and safety. The goal of transportation research is to develop solutions to the Nation's most pressing challenges and find transformative opportunities that will meet future needs.

The responsibility of the federal government is to fund and conduct R&T activities of national interest that will lead to finding solutions to highway transportation issues and significantly advance technology innovation with a clear public benefit when private investment is neither present nor sufficient. FHWA coordinates with State departments of transportation (DOTs), and local agencies, industry, and academia because, in addition to conducting research, those agencies are responsible for deploying and implementing

research products and innovations on State and local transportation systems.[2]

This *FHWA 2015 R&T Story* presents some of the national highway transportation challenges, and discusses how the research and innovations conducted or sponsored by FHWA address these challenges and contribute to changes and improvements in the transportation system. This document also highlights a variety of research projects and activities that demonstrate FHWA's positive and long-lasting impact on the national highway transportation system.

Highlighting Impacts of Research

- FHWA developed geosynthetic reinforced soil-integrated bridge system (GRS-IBS) technology. This accelerated bridge construction method for bridges saved State DOTs millions of dollars (15 to 60 percent in construction and design costs) and significantly reduced construction time—thereby minimizing construction zone closures and inconvenience to drivers.
- FHWA investigated "Safety Edge$_{SM}$" technology to determine whether tapering the edge of a road would help drivers to navigate back on the road. According to the 3-year crash analysis, the benefits outweighed the costs by as much as 63 to 1. Most importantly, Safety Edge can contribute to saving lives by reducing the potential for rollovers and other severe crashes.
- Brought to the U.S. by FHWA, use of warm- instead of hot-mix asphalt reduces fuel consumption, greenhouse gas emissions, and paving costs, while extending the paving season and potentially improving compaction. To date, 41 State DOTs and all Federal Lands Highway divisions have specifications for using warm-mix asphalt. In 2013, warm-mix asphalt is estimated to have reduced emissions by 2 million tons (the equivalent of removing 200 thousand vehicles off the roads). And to expand on the environmental benefits, FHWA is conducting additional research to develop well-founded guidance for using warm-mix asphalt in combination with a high content of recycled materials, such as reclaimed asphalt pavement, to achieve durable pavements.
- FHWA's research provided the details for connecting Prefabricated Bridge Elements and Systems and knowledge on Slide-in Bridge Construction to enable State DOTs to shorten the time needed for work zones and road closures.

This finished 7-inch whitetopping surface with pavement marking was completed as part of an FHWA Highways for LIFE supported pavement rehabilitation with North Dakota DOT. (Image source: FHWA)

FHWA's bridge replacement research has reduced construction times, decreasing congestion and increasing the mobility of goods and passenger travel. (Image source: FHWA)

- FHWA transitioned a good idea into a great idea by furthering the development of the diverging diamond interchange (DDI), a new method of navigating through busy highway intersections, which improves safety for motorists and pedestrians at highway interchanges while reducing congestion.
- FHWA developed a Project Finance Primer to help agencies compare various approaches to planning and delivering expensive construction projects, such as evaluating the difference between funding projects through conventional design-bid-build projects or using public-private partnerships.
- FHWA promotes innovation development with small businesses:
    - Migma Systems developed a new stereovision-based approach for detecting pedestrians at intersections. Based on a concept borrowed from military tracking, the company used a new light-emitting diode (LED) stereo camera and advanced pedestrian-detection algorithms to distinguish pedestrians and vehicles on the roadways. Information from the project can be used in connected-vehicle research to greatly reduce pedestrian fatalities.
    - Solar Roadways envisions replacing current asphalt or concrete surfaces with modular solar road panels: structurally engineered solar panels that replace conventional paving on roadways. The intent of the research is to demonstrate the potential for developing structural pavement panels that can convert solar radiation to electricity and disseminate the power to meet local electricity demands.

The full impact of transportation research and innovations is usually realized over years or decades as the products are implemented across the transportation system and advance the state of the practice. Research results, when implemented appropriately, can save millions of dollars, save lives, extend the life of highway infrastructure, reduce congestion, improve travel time, increase productivity, and positively affect the environment. FHWA's research, guidance, and efforts provide State DOTs and local agencies with the leadership and support needed to address new and shifting challenges.

Showcasing Research of National Significance through the FHWA R&T Agenda

Within FHWA, hundreds of research projects are underway to develop innovations and solve the country's pressing transportation problems. Because transportation comprises many disciplines, from human factors to structural engineering to environmental and safety planning and engineering, an extensive depth and breadth of knowledge is necessary to address the challenges facing our transportation system.

The FHWA R&T Agenda was developed to communicate a comprehensive plan for the Agency. The plan provides a collaborative platform to address national transportation challenges and transparency into research activities. Stakeholder input also enables a deeper understanding of the challenges and issues at the local and State levels.

The *FHWA 2015 R&T Story* provides a framework for how FHWA research will meet six of the Nation's high-priority highway challenges:

- *Advancing Safety Toward Zero Deaths*—a highway system free of fatalities.
- *Improving the Mobility of People and Goods*—moving people and goods, reliably and safely, to where they need to go.
- *Preserving the Nation's Infrastructure*—keeping pavements, bridges, and structures in good condition.
- *Enhancing System Performance*—decreasing highway congestion, safety risks, and wear-and-tear on roadways.
- *Promoting Environmental Sustainability*—improving public health, enhancing the environment, and conserving natural resources.
- *Preparing for the Future*—transforming big ideas into the innovations of tomorrow.

Addressing these six challenges requires the cooperation and collaboration of numerous stakeholders in the public and private sectors, academia, industry, and the international community. FHWA has developed partnerships with many of these stakeholders, offering a way for transportation stakeholders to become involved with and contribute to developing a stronger transportation network.

The remainder of this *FHWA 2015 R&T Story* highlights six key challenges facing the Nation's transportation network, and demonstrates how FHWA R&T solutions advance the Nation's mobility, well-being, and economic security.

Leading Highway Research Across the Globe

A Culture of Innovation at Turner-Fairbank Highway Research Center

FHWA's Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA, plays a vital leadership role in developing and implementing coordinated highway R&T with other research entities within the U.S. and internationally.

TFHRC houses more than 20 laboratories, data centers, and support facilities; and conducts and sponsors applied and exploratory advanced research on vehicle-highway interaction, nanotechnology, safety, pavements, bridges and other highway structures, human-centered systems, operations and intelligent transportation systems (ITS), and materials. Researchers and engineers with expertise in a variety of disciplines (e.g., engineering, chemistry, and psychology) support TFHRC's mission.

TFHRC not only delivers cutting-edge in-house research, but also collaborates with a wide range of researchers across the Nation and around the world. The center's laboratories provide FHWA, the U.S. Department of Transportation (USDOT) modal agencies, other Federal agencies, and State DOTs and local agencies with vital resources for advancing the body of transportation knowledge. TFHRC actively engages in formal collaborations with the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), and the Forum of European National Highway Research Laboratories. In addition, there are informal collaborations with researchers in U.S. companies, academia, and other federal and local agencies, resulting in joint peer-reviewed papers and shared research methods. TFHRC also engages in cooperative research and development (R&D) agreements with the private sector and academia to explore and build new highway-related technologies. To work on projects

of mutual interest, TFHRC hosts visiting researchers from a variety of organizations.

Through the National Research Council Research Associateship Program, TFHRC sponsors post-doctoral and senior research associates who work closely with center staff on research that is relevant to FHWA's challenges and contributes to the associates' professional development. The program attracts skilled associates at the cutting edge in their disciplines, and allows FHWA to focus associates' talents on significant problems. Many associates continue working in transportation research and contribute to the Agency's research after finishing the program.

With TFHRC providing research, development, and technology management, the FHWA R&T Agenda articulates the objectives that guide the Agency's research, development, and deployment activities to strengthen and improve the National Highway System. The *FHWA 2015 R&T Story* also identifies the strategies that FHWA is pursuing to achieve those objectives, and selected activities that target one or more of the Nation's six key highway challenges. Take a look at the following research highlights that contribute to enhancing and improving the national transportation system.

Accelerating Innovation, Every Day Counts

In 2009, FHWA launched Every Day Counts (EDC) in cooperation with the AASHTO to speed up the delivery of highway projects and to address the challenges presented by limited budgets. EDC is a State-based model to identify and rapidly deploy proven but underutilized innovations to shorten the project delivery process, enhance roadway safety, reduce congestion and improve environmental sustainability. A key component of implementing new technology is nurturing a State-based network for the deployment of innovation. To support this concept the FHWA established the State Transportation Innovation Council (STIC) Incentive Program and the Demonstration Project Program to help States institutionalize innovations and meet their innovation deployment goals.

For More Information

The following Web sites provide additional information and further highlight the transportation challenges and FHWA activities discussed above.

Geosynthetic Reinforced Soil Integrated Bridge System, Synthesis Report: https://www.fhwa.dot.gov/publications/research/infrastructure/structures/11027/11027.pdf.

Safety Edge$_{SM}$ technology: http://www.fhwa.dot.gov/everydaycounts/technology/safetyedge/intro.cfm.

Warm Mix Asphalt Technologies and Research: http://www.fhwa.dot.gov/pavement/asphalt/wma.cfm.

Prefabricated Bridge Elements: https://www.fhwa.dot.gov/everydaycounts/technology/bridges/intro.cfm.

Diverging Diamond Interchange FHWA YouTube video: https://www.youtube.com/watch?v=eLAwwl3EtN4.

Project Finance Primer: http://www.fhwa.dot.gov/ipd/finance/resources/general/.

Small Business Innovation Research (SBIR): http://www.volpe.dot.gov/work-with-us/small-business-innovation-research.

AP Story—Inventor Pushes Solar Panels for Roads, Highways: http://bigstory.ap.org/article/inventor-pushes-solar-panels-roads-highways.

Every Day Counts: http://www.fhwa.dot.gov/everydaycounts/.

State Transportation Councils: http://www.fhwa.dot.gov/stic/.

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1. Federal Highway Administration (2011). "Our Nation's Highways: 2011." (Web page) Washington, DC. Accessed online: September 9, 2014. (http://www.fhwa.dot.gov/policyinformation/pubs/hf/pl11028/chapter1.cfm)
2. Transportation Research Board (2008). *TRB Special Report 295, The Federal Investment in Highway Research, 2006–2009: Strengths and Weaknesses.* Transportation Research Board, Washington, DC.

Advancing Safety

Safety is the U.S. Department of Transportation's (USDOT's) top priority and is underscored throughout FHWA's research areas.

In 2012, 33,561 people died as a result of motor vehicle crashes.[3] While this figure reflects a continuing decline in fatalities, even one death is too many. That is why FHWA research continues to seek innovative approaches and technologies that support the USDOT vision of advancing toward zero deaths and serious injuries.

Highway safety is considered for every FHWA program and is important in the systematic planning, management, and evaluation of roadway research efforts across the Nation. FHWA also equips State and local agencies with the tools and knowledge to deliver significant safety improvements to the public. For example, implementing roundabouts and new designs at busy intersections have reduced fatal crashes, and improvements to existing roadway conditions have enhanced both pedestrian and bicyclist safety.

FHWA's safety research also focuses on the causes of roadway fatalities and injuries by closely examining highway designs, road construction practices, and maintenance

Examples of FHWA research and innovation delivery activities:

- Improving Data and Tools for Safety Analyses
- Improving the Safety of Pedestrians and Bicyclists
- Analyzing and Testing Roadside Safety and Security Barriers
- Looking Ahead Toward Driver Behavior Analysis and New Connected Vehicle Technology

Above: President Obama visits FHWA's driving simulator. Below: The full-scale driving simulator enables FHWA to study drivers in real-world conditions. (Images: FHWA)

operations. These efforts have resulted in the development of strong data analysis tools that enable transportation professionals and researchers to connect crash causes with effective solutions.

Research Activities

Research activities are connected directly to FHWA safety-related objectives. Each of the activities described below promotes safety improvement initiatives for motorists, pedestrians, and bicyclists.

Improving Data and Tools for Safety Analyses

Collecting and analyzing data are major components of any safety improvement program. This is why one of FHWA's strategic safety goals is to improve safety data and expand capabilities for analysis and evaluation.[4] FHWA is committed to making data-driven decisions that optimize investments in safety improvements to the Nation's roads. As an example, FHWA leads an effort called Evaluations of Low Cost Safety Improvements Pooled-Fund Study (ELCSI-PFS), which involves 38 State DOTs and impacts the direction of safety research and its application nationwide. The goal of the ELCSI-PFS research is to create reliable estimates of the effectiveness of low-cost safety improvements identified as strategies in the *National Cooperative Highway Research Program (NCHRP) Report 500 Guidebooks.* The ELCSI-PFS estimates are determined through scientifically rigorous before-and-after evaluations at locations in the U.S. where these strategies are field tested.

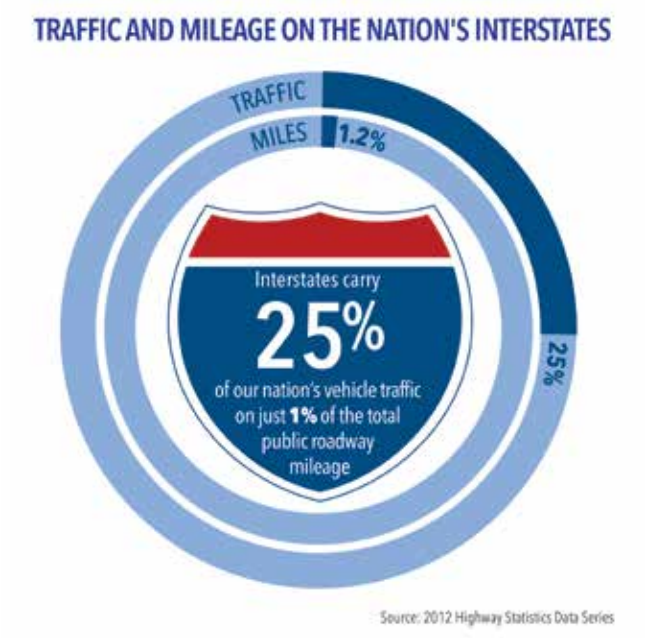
One example of an ELCSI-PFS study conducted in 2014 was titled, Safety Evaluation of Centerline plus Shoulder Rumble Strips. The intent of the rumble strip countermeasure is to reduce the frequency of crashes by alerting drivers when they are about to leave their travel lane. Data were collected on two-lane rural road locations using rumble strips in Kentucky, Missouri, and Pennsylvania. The results showed a 23 percent decrease in fatalities and injuries combined. An economic analysis revealed that the combination of shoulder and centerline rumble strips is a very cost-effective treatment with benefit-cost ratios ranging from 11:1 to 30:1.

FHWA's field research vehicle can study drivers' eye movements in real world settings, collecting valuable data on driver distractions. (Image source: FHWA)

FHWA has also developed a number of innovative tools to collect and evaluate roadway and vehicle data in order to identify and address critical safety issues and hazards. One example is the Interactive Highway Safety Design Model (IHSDM), which is a suite of six software modules used to evaluate the safety and operational effects of geometric design decisions.[5] The IHSDM includes the Crash Prediction Module, which estimates the number of crashes that can be expected on a current or proposed design of a particular highway segment. The crash estimate helps designers and planners identify the combination of design details—such as curvature, grade, cross slope, and intersection location and design—that will minimize future crashes at a specific location. Another module, the Policy Review Module, checks the current or proposed roadway design details on a given road segment, to see how well that design matches current design policies in that locale. The Crash Prediction Module is valid for rural two-lane roads, rural multilane roads, urban/suburban arterials,

freeway segments, and ramps and interchanges. At present, the other five modules pertain only to rural two-lane roads.

The Nevada DOT performed an analysis on a section of Nevada State Route (SR) 147 in Clark County over a 20-year period (2013-33). SR 147 is a low-volume, rural, two-lane highway with an abnormally high number of fatal and injury crashes over the last several years. Expected crash totals were estimated using the IHSDM to evaluate and prioritize safety improvement alternatives. Each alternative and the existing road conditions were entered into the IHSDM to predict the crashes for the next 20 years based on the geometry, projected traffic volumes, and the crash history along the corridor. The alternatives were evaluated independent of each other to see their impact and safety benefit on the corridor. Projected reductions in crashes for 2013-33 ranged from 1 percent for superelevation improvements, which pertain to banking adjustments along a horizontal curve, to 21 percent for shoulder widening.



U.S. Interstates carry 25 percent of the Nation's traffic, making highway safety a primary concern for FHWA. (Image source: FHWA)

Improving the Safety of Pedestrians and Bicyclists

A vital aspect of FHWA's R&T activities is to collaborate with State and local agencies, and Tribal Lands, to identify safety challenges facing pedestrians and bicyclists; to develop tools, technologies, and countermeasures, which can address those problems; and to support our partners in applying those research results to their specific needs. A good example of that collaboration is the Haxton Way Pedestrian Pathway Project.

Located in Whatcom County in Bellingham, Washington, Haxton Way is a narrow, two-lane road with a fog line and only a few inches of paved shoulder. A fog line is the white line painted on the right side of the road that is used by drivers to maintain a vehicle in the center of the lane in areas of heavy fog. Pedestrians and bicyclists use the roadway to access essential community amenities. Over the years, a number of pedestrians and bicyclists have been struck and killed while traveling along this roadway.

To improve safety, the Lummi Nation Planning Department in partnership with Whatcom County, Washington State DOT, the Bureau of Indian Affairs, and FHWA administered the project to construct an elevated, 8-foot-wide multiuse path on wetlands next to Haxton Way. Low-voltage, solar-powered LED lamps were installed along the new trail to provide low-intensity, environmentally friendly, and cost-efficient lighting. Each lamp, equipped with motion, light, and proximity sensors, is set to provide 25 percent brightness after sunset, but the brightness increases to 100 percent as walkers or cyclists approach each lamppost. Choosing an environmentally friendly lighting solution in a sensitive ecosystem reduced the mitigation impacts that are normally associated with conventional lighting.

On this stretch of roadway, zero injuries, deaths, or crashes have been reported since project completion. Local citizens and Tribe members now feel safe walking or biking along the amply lit pathway, well

FHWA created an environmentally sensitive, multiuse path beside the Haxton Way in Washington that eliminated fatalities on roadway shared by pedestrians, bicyclists, and motorists. (Image source: FHWA)

away from oncoming cars and the congested roadway. Construction of the Haxton Way Pedestrian Path was funded by FHWA, which also provided overall project stewardship, oversight, and technical assistance throughout the project development process.

Analyzing and Testing Roadside Safety and Security Barriers

Keeping travelers safely on the roadway is a top priority for FHWA, where the focus is on developing roadside safety features that guide travelers' vehicles back on the roadway when they stray, and that minimize the consequences to travelers when their vehicles depart the roadway. To do this, FHWA uses cutting-edge computer simulations, including advanced finite element modeling and full-scale crash tests to examine the effectiveness of features such as roadside safety barriers and security barriers.

FHWA-sponsored research proves that the effectiveness of cable median barriers can be affected by the position of the barrier within the median cross section. Cable median barrier research was prompted by cross-median crashes in which vehicles slid under generic three-cable, low-tension barriers placed along the centerline of V-shaped medians with sloped sides. Part of the problem was attributed to vehicle dynamics resulting from suspension system compression and vehicle rebound once the car left the road surface and crossed the slope. A total of 72 terrain tests were conducted at FHWA's Federal

FHWA's Federal Outdoor Impact Laboratory tests safety barriers like the one above to improve their design and construction. (Image source: FHWA)

Outdoor Impact Laboratory (FOIL), involving different vehicles at various speeds traveling through different V-shaped medians. These tests were conducted to gather validation data for all the vehicle dynamic simulations needed for these cable barrier studies. This research showed that even a 3-foot difference in lateral placement of the barrier improved how the vehicle made contact with the barrier, leading to fewer vehicle underrides.

Keeping employees safe and protecting vital government facilities from terrorist threats at home and abroad is essential for sustaining employee confidence and maintaining workforce efficiency. Security barriers are used to harden the perimeter of Government buildings and critical facilities, preventing the unwanted intrusion of speeding motor vehicles. FHWA works closely with the Department of State (DOS) to keep vehicular bomb threats as far as possible from diplomatic and government buildings by researching, testing, and constructing perimeter anti-ram fences and barriers. FHWA is collaborating with the DOS to create cutting-edge computer models and crash simulations that closely examine the effectiveness of security barriers. Full-scale crashes are conducted at FOIL to test and improve the design, application, construction, and deployment of infrastructure security barriers.

Looking Ahead Toward Driver Behavior Analysis and New Connected Vehicle Technology

Looking ahead, Safety R&D will continue to develop, refine, and deploy advanced data capture and analysis tools to improve safety decisionmaking and save lives. TFHRC is establishing a new Safety Training and Analysis Center that will be a source for training and technical support for State DOTs and research partners who want to use the safety-data sets from the Second Strategic

Highway Research Program (SHRP2) Naturalistic Driving Study to gain insights into driver behavior.

Analysis of the SHRP2 safety data will help researchers understand how drivers react to their entire environment, inside and outside the vehicle, which will help to improve roads, vehicles, driver training, and enforcement measures thus reducing the number of crashes and resulting injuries.

Through the Exploratory Advanced Research Program (EAR), FHWA is also funding the development of other software tools to automate the extraction of information from massive video datasets so that the widest possible range of researchers will be able to use SHRP2 safety data.

Safety R&D is leading research into how new automotive technologies like connected vehicles and automated vehicles can be harnessed to prevent crashes. These technologies aim to enable safer vehicles and roadways by developing better crash avoidance, performance measures, and infrastructure-based cooperative safety systems to facilitate the communications among vehicles and the roadside. Safety R&D is actively engaged in how these technologies can help people avoid crashes, through new safety advisories, warnings, and messages to augment the driver's situational awareness.

FHWA is contributing to several aspects of the Connected Vehicle Program. For example, the Human Factors Laboratory, at TFHRC, is using its state-of-the-art driving simulator to collect data and evaluate how drivers' abilities and limitations may influence Cooperative Adaptive Cruise Control (CACC) system performance and design.

The next generation of vehicle technology, coupled with the advances in safety research that have been realized to date, will enable USDOT to achieve its vision of Toward Zero Deaths.

Improving Safety for Motorists, Pedestrians, and Bicyclists

The research being conducted by FHWA supports the USDOT's and FHWA's safety commitment by applying focused, collaborative, and strategic research methods that result in innovations and new technologies. FHWA promotes a safety culture that relies on scientific methods and data-driven decisionmaking for transportation-related programs and projects. FHWA's efforts are leading to reductions in traffic crashes, fatalities, and injuries on our Nation's roads and highways, and the Agency will continue to encourage and promote this science-based research now and into the future.

For More Information

The following Web sites are provided for additional information, and further highlight the transportation challenges and FHWA activities discussed above.

Lummi Nation Haxton Way Pedestrian Pathway Project: https://www.fhwa.dot.gov/planning/processes/tribal/case_studies/lummi.pdf.

Haxton Way YouTube Video: https://www.youtube.com/watch?v=ltR2oiQ3R9Q.

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3. National Highway Traffic Safety Administration, *Traffic Safety Fact 2012,* Washington, DC. Accessed online: July 30, 2014. (http://www-nrd.nhtsa.dot.gov/Pubs/812032.pdf)
4. Federal Highway Administration (2014). "Roadway Safety Data Program." (Web page) Washington, DC. Accessed online: July 30, 2014. (http://safety.fhwa.dot.gov/rsdp/about.aspx)
5. Federal Highway Administration (2014). "Interactive Highway Safety Design Model (IHSDM): Overview." (Web page) Washington, DC. Accessed online: July 30, 2014. (http://www.fhwa.dot.gov/research/tfhrc/projects/safety/comprehensive/ihsdm/)

Improving the Mobility of People and Goods

A growing economy needs highways that safely and reliably move people and goods where they need to go.

Traffic congestion on urban roads and highways has become increasingly problematic. Roughly 40 percent of average travel delays now occur outside normal rush-hour periods.[6] Traffic conditions are becoming less consistent from day to day, forcing commuters to factor even more "buffer time" into their trips to ensure on-time arrival, according to an annual nationwide study by the Texas A&M Transportation Institute.[7] In 2010, congestion and delay on the Nation's highways accounted for more than $100 billion in lost time and wasted fuel, and in 2012, the average commuter wasted 38 hours in traffic and spent an extra $818 in fuel costs due to congestion. These congestion delays increase driver dissatisfaction and adversely impact the ability of businesses to deliver goods and services.

Agencies have a limited ability to add new roads to relieve growing congestion; therefore, they must look to new

Examples of FHWA research and innovation delivery activities:

- Streamlining Traffic Flow with Adaptive Signal Control Technology
- Reducing Congestion with Cooperative Adaptive Cruise Control
- Improving Mobility and Safety with Automated Vehicles

Above: Vehicle-to-infrastructure technology for connected vehicles can help motorists safely navigate busy intersections. Below: Cameras on traffic signals linked to connected vehicles can alert drivers to pedestrians or bicyclists in a crosswalk, improving safety and mobility for all. (Images: FHWA)

technologies that help maximize the capacity of existing roadway infrastructure and make transportation more reliable. A reliable highway system helps set commuter expectations of travel times so that they can plan their trips more effectively. Reliability also ensures the just-in-time delivery of goods that drives the Nation's retail and manufacturing economy. Improved system operations and reliability better enables people to access jobs, deliver key services and products, reach needed amenities, and contribute to the national economy.

Through operations research, development, and testing, FHWA is advancing new technologies and innovative processes to increase highway capacity, reduce traffic congestion and unreliability, and improve traffic analysis techniques. FHWA sponsors research on automated and connected vehicle applications that could potentially double the practical capacity of dedicated freeway lanes[8] and save fuel. FHWA's research includes simulation studies of the benefits of these applications, and efforts are underway to develop prototype applications for field testing.

Research and traffic management best practices give State and local agencies the tools to solve operational challenges. Improved, real-time management of disruptions, such as adverse weather and crashes, enables transportation agencies to maintain a reliable highway system even when traffic volume is high or when incidents occur. FHWA helps agencies employ innovative tools to assist with real-time management, including traffic and weather sensors, wirelessly connected vehicles, remote management of traffic signals, automated vehicles, and adaptive cruise control. At the forefront of bringing these innovative technologies into the mainstream, FHWA is helping transportation agencies incorporate 21st century tools and policies in their own practices.

Research Activities

The activities described in this section are examples of research, tools, and innovative technologies that FHWA is supporting to improve mobility and sustain the Nation's highway system. One of FHWA's primary objectives is to manage congestion by improving highway reliability and operating the system at peak performance.

Streamlining Traffic Flow with Adaptive Signal Control Technology

The goal of traffic signal timing is to maintain the safe and efficient flow of vehicles at intersections. Poor traffic signal timing accounts for more than 10 percent of all traffic delay and congestion on major routes. Conventional signal control systems rely on preprogrammed, daily signal timing schedules, which require an extensive amount of traffic data that must be collected manually. Conventional signal control systems also do not accommodate variable and unpredictable traffic demands, such as special events. Older signal timing systems cause substantial losses for businesses and consumers due to decreased productivity and increased labor costs.

Adaptive signal control technology (ASCT) adjusts the timing of red, yellow, and green lights to accommodate changing traffic patterns. ASCT uses real-time traffic information to reduce congestion by determining which lights should be red and which should be green. The main benefits of ASCT are that it:

- Equitably distributes green light timing for all traffic movements.
- Improves travel time reliability by progressively moving vehicles through green lights.
- Prolongs the effectiveness of traffic signals and their associated timing.
- Reduces emissions due to improved traffic flow.

On average, ASCT improves travel time by more than 10 percent. In areas with particularly outdated signal timing, improvements can be greater than 50 percent. Starting in the early 1990s, FHWA developed and demonstrated four ASCT approaches for

dynamically updating signal timing. Following the positive results of this foundational research, FHWA initiated an effort to expand the deployment of ASCT systems across the Nation. This deployment effort has contributed to a 192 percent increase in implementation from 2009-2014, with multiple ASCT products now available in the marketplace.[9]

Reducing Congestion with Cooperative Adaptive Cruise Control

FHWA researchers envision that drivers will share vehicle control with an automated system that includes pervasive vehicle-to-vehicle (V2V) and infrastructure-to-vehicle (V2I) connectivity via Dedicated Short-Range Communications (DSRC). DSRC are one- or two-way short- to medium-range wireless communications designed specifically for use in vehicles. Cooperative Adaptive Cruise Control (CACC) allows vehicles to use DSRC to broadcast their speed, following distance, and acceleration and deceleration rates to other CACC-equipped vehicles. Vehicles equipped with CACC use this information to automatically apply the brakes as needed to maintain a safe distance from the vehicles ahead, allowing for closer following distances and for more vehicles to safely use the existing roadway. FHWA is conducting research to identify and analyze early CACC concepts and assess the range of possible benefits, which the agency anticipates will include increased vehicle efficiency and reduced fuel use. FHWA is also funding research on CACC specifically for trucks, called "truck platooning."

Connected vehicles can also use DSRC to broadcast performance data to roadway infrastructure to track traffic flow and crashes or incidents. FHWA will use the performance data to develop predictive traffic models for more effective traffic management.

Improving Mobility and Safety with Automated Vehicles

Automated vehicle technology has the potential to streamline mobility, lower the number of traffic crashes, decrease congestion, and reduce the high costs associated with lost time and wasted fuel. The technology also could create safer and more efficient travel for those with mobility issues.

Automated vehicles are precisely controlled, using advanced wireless communications, onboard computers, advanced vehicle sensors, and Global Positioning System (GPS) navigation. FHWA has identified opportunities where automation can significantly enhance the operation of the highway transportation system. Research sponsored by FHWA suggests that significant public benefits in terms of mobility, fuel use, emissions, and safety can be achieved through the introduction of some partially automated systems where drivers maintain control of the steering function while automated systems control the vehicle speed. Several States are testing automated vehicle technologies that could lead to future innovations.

Creating a Safer, More Reliable Transportation System

As more drivers put pressure on the transportation system, FHWA is identifying solutions to make roadways safer and travel times more reliable for everyone. Streamlining the movement of vehicles is about more than improving driver experience; it affects the Nation's ability to remain economically competitive. FHWA works diligently to provide tools and promote innovations that will solve the challenges of traffic congestion and delay. Ensuring that people are able to travel reliably and that goods and services are delivered efficiently is paramount. To be successful in this area, FHWA is looking at 21st-century technologies and tools that will bridge the gap between old and new traffic management strategies.

FHWA research in arterial management seeks to improve traffic flows in congested intersections. (Source: FHWA Adaptive Signal Control Program)

For More Information

The following Web sites are provided for additional information, and further highlight the transportation challenges and FHWA activities discussed above.

Exploratory Advanced Research (EAR) Program Fact Sheet - Beyond Traffic Signals: A Paradigm Shift: http://www.fhwa.dot.gov/advancedresearch/pubs/10023/10023.pdf.

Cooperative Adaptive Cruise Control: Applications Development and Research: http://www.its.berkeley.edu/publications/UCB/2011/PRR/UCB-ITS-PRR-2011-9.pdf.

Cooperative Adaptive Cruise Control: Human Factors Analysis: http://www.fhwa.dot.gov/publications/research/safety/13045/index.cfm.

Adaptive Signal Control: http://www.fhwa.dot.gov/everydaycounts/technology/adsc/.

FHWA R&T Research Technology Agenda: http://www.fhwa.dot.gov/research/fhwaresearch/agenda/index.cfm.

6. Jones, S (2013). *Cooperative Adaptive Cruise Control: Human Factors Analysis.* Federal Highway Administration, Washington, DC.

7. Texas A&M Transportation Institute (2012). *2012 Annual Urban Mobility Report.* College Station, Texas. Accessed online: July 30, 2014. (http://mobility.tamu.edu/ums/)

8. Kuehn, David and Fitzgerald, Mark. (November/December 2013). "Breakthroughs to the Future." *Public Roads.* http://www.fhwa.dot.gov/publications/publicroads/13novdec2013/01.cfm

9. Federal Highway Administration (2014). Unpublished, raw data. For additional information, contact the FHWA Resource Center and Office of Operations: http://ops.fhwa.dot.gov/arterial_mgmt/index.htm. Washington, DC.

Preserving the Nation's Infrastructure

To keep pavement, bridges, and other types of infrastructure in a state of good repair, FHWA fosters innovations that increase longevity while enabling improved monitoring of road conditions.

As the Nation's transportation infrastructure ages, maintaining the highway system in a state of good repair will become significantly more complicated and expensive. According to FHWA in 2012, more than 66,000 bridges in the U.S. were rated as structurally deficient. Structural deficiencies are characterized by deteriorated conditions of significant bridge elements and potentially reduced load-carrying capacity.[10]

The investment required to rebuild these bridges is estimated to be more than $51 billion.[11] FHWA's research is forward-looking, and supports advancement of innovative materials and designs, improved infrastructure management and preservation practices, better construction techniques, and improved quality control to advance infrastructure safety, longevity, and environmental sustainability.

Top: Trucks deliver concrete for the deck of the existing Paseo Bridge in Missouri as part of a project that used innovative design techniques to accelerate bridge construction. Above: FHWA and Oregon DOT use accelerated bridge construction to rapidly remove and replace five bridges on Oregon 38. Rapid bridge replacement technology used hydraulic jacks mounted on a sliding rail to slide the old superstructure onto temporary supports and move the new superstructures into their final position. (Images: FHWA)

Examples of FHWA research and innovation delivery activities:

- Accelerating Infrastructure Construction and Assessment
- Accelerating Bridge Construction to Reduce Congestion
- Improved Bridge Deck Condition Assessments via the RABIT™ Bridge Deck Assessment Tool
- Producing Low-Cost, Long-Lasting Rockery Retaining Walls
- Developing Rapid Post-Disaster Recovery Assessment

Research Activities

FHWA is pursuing a variety of research to address highway infrastructure challenges. For example, FHWA is researching new methods and processes to accelerate infrastructure construction, such as precast concrete deck panels in bridge construction. Efforts to help highway agencies effectively assess and manage infrastructure include pursuit of innovative tools to evaluate bridge deck conditions, and post-hazard assessment guidelines for flooded roadways. The research activities below illustrate FHWA's important role in each of these areas with specific examples of innovative solutions.

Accelerating Infrastructure Construction and Assessment

Roughly 10 percent of the Nation's 600,000 bridges require major rehabilitation, repair, or complete replacement.[12] The work that occurs on the construction site can significantly impact mobility and safety. In some cases, the direct and indirect costs of traffic detours or road closures as a result of bridge construction far exceed the cost of the structure itself.[13]

FHWA has initiated a number of projects to speed up or accelerate infrastructure construction and preserve existing infrastructure. FHWA research has led to the Accelerated Bridge Construction (ABC) processes, which include innovative planning, design, materials, and composite construction methods, in a cost-effective manner to build or replace bridges. As part of the deployment initiative, Every Day Counts, most States are using one or more ABC techniques. ABC can lead to reduced agency costs, improved motorist and worker safety, improved mobility around bridge construction projects, better initial quality if using prefab components, and more durable and lasting bridges. ABC technologies include the following:

- *Prefabricated bridge elements and systems* (bridge components built offsite, or adjacent to the

Construction of the roadway surface nears completion on the Christopher Bond Bridge construction project in Kansas City, Missouri. The innovative side-by-side bridge constructive technique saved time and minimized road closures. (Image source: FHWA)

Placing of rebar prior to concrete pour during construction of a pylon on Christopher Bond Bridge construction project was one of many cost-effective, technical engineering solutions that saved time and provided flexibility in the bridge construction schedule. (Image source: FHWA)

alignment, reducing onsite construction time and mobility).

- *Geosynthetic reinforced soil-integrated bridge system* (use of alternating layers of compacted granular fill encapsulated by geotextile fabric sheets to build support for the bridge.)
- *Slide-in bridge construction* (new bridge built on temporary supports parallel to an existing bridge and upon completion the old bridge is demolished and a new bridge is slid into place, tied into the approaches, and paved within 48 to 72 hours).

The impact of using these innovations can be seen in the following examples:

- Nevada used slide-in bridge construction and shut down a road for only 56 hours to replace a bridge, saving an estimated $12.7 million in time and fuel costs for commuters.
- Sandy Township in Clearfield County, Pennsylvania replaced a bridge using the geosynthetic reinforced soil-integrated bridge system with its own equipment and workforce in only 35 days, saving months of detours and delays.

Accelerating Bridge Construction to Reduce Congestion

Conventional bridge deck construction follows an onsite sequential process: building the substructure, construction and placement of either steel or concrete superstructure girders, followed by concrete bridge deck curing. These activities can impede traffic flow, causing travel delays for the motoring public and reducing safety for drivers, pedestrians, and construction personnel. ABC strategies have gained traction because they shorten project delivery, enhance roadway safety, and protect the environment.

Prefabricated, full-depth concrete deck panels are increasingly used in ABC processes in which modular components of a deck are precast off-site and then joined together at the bridge construction site. Modular precast concrete deck panels improve the safety and efficiency of the bridge construction process. Roadwork can be completed overnight, on weekends, and during off-peak hours, reducing congestion, road closures, and work zones. Since October 2010, more than 2,496 replacement bridges have been designed or constructed using prefabricated bridge elements and systems. Successful applications of full-depth precast concrete deck panels include the US-24 Mississippi River Bridge in Illinois and the 24th Street Council Bluffs in Iowa.

Precast concrete deck panels are placed on top of concrete or steel bridge girders and a composite connection is formed with the girders. For panels placed on steel girders, they are connected using shear studs that were previously welded to the girders. Deck panels have pockets that fit around the shear studs and are then filled with grout or concrete to form a composite bond with the steel girder.[14] For precast deck construction, it is advantageous to cluster the

The RABIT™ bridge deck assessment tool is eight times faster than conventional methods at collecting data on the conditions of a bridge's deck and subsurface. (Image source: FHWA)

studs closer together and increase the distance between the clusters, which simplifies panel fabrication and constructability.

FHWA is conducting full-scale static and fatigue tests of composite beams constructed with steel beams and precast concrete deck panels, seeking to increase the space between clusters to make conditions more favorable to precast concrete deck panel construction.

Improved Concrete Bridge Deck Condition Assessments via the RABIT™ Bridge Deck Assessment Tool

One way to reduce the number and cost of bridge rehabilitation projects is to identify the anticipated future condition concerns of a bridge deck. FHWA's Long-Term Bridge Performance program developed a multifunctional research tool to better characterize the condition of bridge decks. The RABIT™ bridge deck assessment tool, invented jointly by FHWA and university researchers, deploys a suite of technologies to help FHWA researchers collect comprehensive data on bridge deck surface and subsurface conditions automatically and simultaneously.

The combination of surface/subsurface tools allows bridge engineers to quickly identify bridge deck areas of concern—corrosion, cracks, and other forms of infrastructure deterioration. Data collected by the RABIT™ bridge deck assessment tool are tagged with GPS coordinates for accurate location reference. Maintenance crews can use those coordinates to locate, inspect, and repair any damaged areas of the bridge deck surface or subsurface. The RABIT™ bridge deck assessment tool can collect data from approximately 4,000 square feet of bridge deck per hour using a combination of onboard nondestructive tools and image processing capabilities, which require a minimum of two people to safely operate. The same assessment using conventional handheld equipment and individual operators would require a minimum crew of five people to collect data at the same resolution as the RABIT™ bridge deck assessment tool. The conventional method is performed at a lower rate of approximately 500 square feet per hour, which would take eight times as long to collect the same amount of data. The RABIT™ bridge deck assessment tool also automatically collects, reduces, stores, and provides a visual representation of all data collected in near real time. In addition, the RABIT™ bridge deck assessment tool minimizes both traffic interruption and exposure of field personnel to hazardous conditions.

Producing Low-Cost, Long-Lasting Rockery Retaining Walls

In November 2006, FHWA developed innovative guidelines to build cost-effective and structurally sound rockeries. Rockeries, or dry stack walls, are rough, natural, onsite rock structures that are stacked and interlocked with no mortar, concrete, or steel. They offer a low-cost, long-lasting, safe, and visually appealing way to retain and protect earth-cut or fill slopes.

Prior to 2006, no standards, specifications, or other accepted procedures existed to provide construction or

FHWA guidelines on building rockeries, like this one on State Route 153 in Utah's Fishlake National Forest, have reduced the cost of building walls by as much as 50 percent. (Image source: FHWA)

design guidance for rockeries; however, rockeries functioned well in many different types of environments, suggesting that excellent performance could be expected when certain conditions were met. A rational, tested design procedure was needed to provide designers and federal landowners with confidence that rockery structures could be used as part of modern highway engineering.

FHWA produced design and construction guidelines to define and evaluate the stability of rockeries given specific geometries (height, base width, and batter); rock properties and placements; and backfill materials. The guidelines also include construction quality assurance steps, standard plan drawings, and construction specifications. Rockeries help meet sustainability goals by using onsite materials, and at the same time they deliver unique context-sensitive solutions. To date, more than 80 rockeries have been built following the guidelines, resulting in a cost of $20 to $30 per square foot, compared with $70 to $100 per square foot for conventional walls.[15] A recent example from Fishlake National Forest in central Utah (constructed at $20 per square foot) is shown in the photo at the top of the page.

Developing Rapid Post-Disaster Recovery Assessment

Floods can cause serious damage to roadways, often undermining the integrity of asphalt, concrete, and gravel roads. After a flood, highway agencies must quickly assess the extent of damage and perform repairs necessary to safely reopen the highway and maintain traffic flow. FHWA is currently conducting research to develop guidelines that transportation agencies can use to evaluate flood impacts on pavements and how quickly damaged roads can be reopened to emergency vehicles. In pursuing this research, FWHA is drawing on the experiences of State agencies responsible for infrastructure impacted by flooding.

Preserving the Nation's Infrastructure

U.S. bridges and highways make up one of the most complex and wide-ranging transportation systems in the world. Maintaining safe infrastructure and its integrity is a priority for FHWA. Infrastructure investments spur economic growth, create well-paying jobs, and enable citizens to reach necessary amenities

more reliably and efficiently. FHWA is advancing new construction techniques, assessment tools, technologies, and more sustainable building materials to construct longer-lasting bridges and highways in less time with reduced costs.

For More Information

The following Web sites are provided for additional information, and further highlight the transportation challenges and FHWA activities discussed above.

Every Day Counts 2012 Initiatives: Accelerated Bridge Construction: http://www.fhwa.dot.gov/everydaycounts/edctwo/2012/abc.cfm.

Accelerated Bridge Construction Fact Sheet: http://www.ops.fhwa.dot.gov/WZ/practices/factsheets/factsheet16/index.htm.

RABIT™ Bridge Deck Assessment Tool Overview: http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/structures/ltbp/ltbpresearch/rabit/index.cfm.

Final Report – Rockery Design and Construction Guidelines: http://www.cflhd.gov/programs/techDevelopment/geotech/rockeries/documents/01_Rockery_Entire_Document.pdf.

10. Federal Highway Administration (2013). “Estimated 2012 Costs to Replace or Rehabilitate Structurally Deficient Bridges.” (Web page) Washington, DC. Accessed online: September 26, 2014. (http://www.fhwa.dot.gov/bridge/nbi/sd2012.cfm)

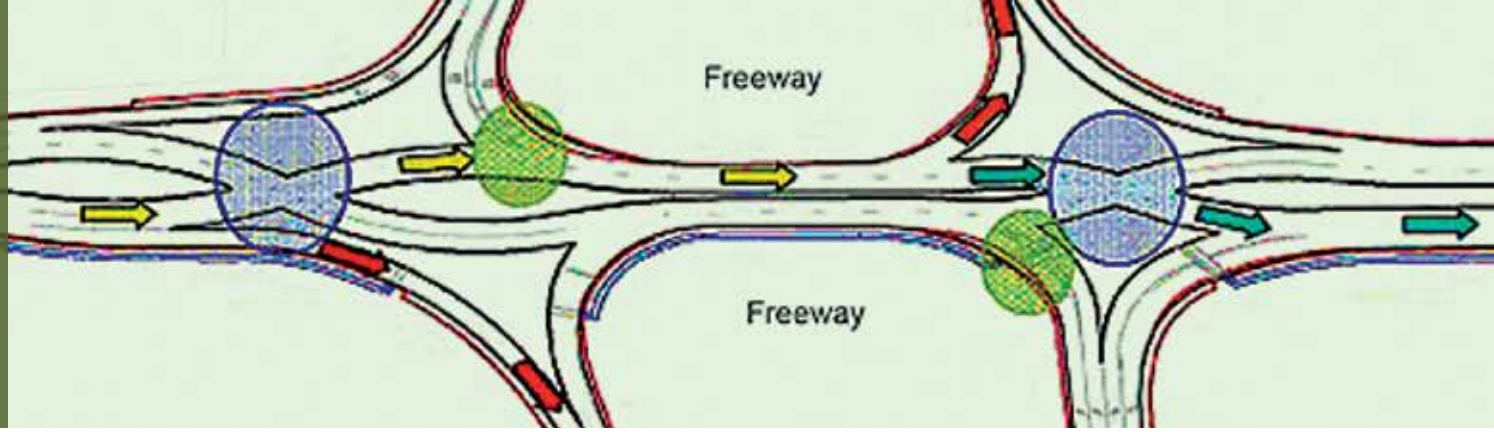
11. Federal Highway Administration (2013). “Estimated 2012 Costs to Replace or Rehabilitate Structurally Deficient Bridges.” (Web page) Washington, DC. Accessed online: September 26, 2014. (http://www.fhwa.dot.gov/bridge/nbi/sd2012.cfm)

12. Federal Highway Administration (2013). “Estimated 2012 Costs to Replace or Rehabilitate Structurally Deficient Bridges.” (Web page) Washington, DC. Accessed online: September 26, 2014. (http://www.fhwa.dot.gov/bridge/nbi/sd2012.cfm)

13. Federal Highway Administration (2013). “Accelerated Bridge Construction.” (Web page) Washington, DC. Accessed online: February 18, 2015. (http://www.fhwa.dot.gov/bridge/abc/)

14. Ocel, J. and Provines, J. (2014). “Strength and Fatigue Resistance of Clustered Shear Studs.” Proceedings of the 2014 World Steel Bridge Symposium. March 26-29, 2014, Toronto, Ontario.

15. Federal Highway Administration (2015). “Research and Technology Agenda. Meeting the Challenge: Federal Lands.” (Web page) Washington, DC. Accessed online: February 18, 2015. (http://www.fhwa.dot.gov/research/fhwaresearch/agenda/researchareas.cfm?urlanchor=federalLands#newhd3)



Enhancing System Performance

Promoting effective tools and research to help decrease highway congestion, safety risks, and wear and tear on roadways.

With limited space and budgets to build more lanes or roads, today's transportation agencies are looking for innovative ways to get the most out of existing roadways.

FHWA is providing the research and tools needed to effectively plan for increased traffic, measure and evaluate roadway performance, and identify desired outcomes that respond to congestion. Improving the performance of the highway system (particularly its safety, reliability, effectiveness, and sustainability) can reduce safety hazards, limit wear and tear on roadways and vehicles, and minimize driver frustration and delay.

Research Activities

FHWA is enhancing system performance through diverse research projects. Examples include studying safer and more efficient ways to merge highway traffic, providing up-to-date freight data that help lower shipping costs, and helping predict future travel demand and driver habits.

Examples of FHWA research and innovation delivery activities:

- Developing Better Intersection Design Saves Lives and Money: Diverging Diamond Interchanges
- Improving the Freight Network for Economic Growth and Commerce
- Fostering Better Transportation Decisions through Better Data

Above: A design drawing for a diverging diamond interchange shows how the novel design reduces turning conflicts in an intersection. Starting from the left, the yellow arrows show a vehicle's progress through the intersection. The red arrows show how the vehicle would merge onto the freeway while the green arrow shows its progress across the overpass. Below: Workers finish construction on a new diverging diamond interchange. (Images: FHWA)

Developing Better Intersection Design Saves Lives and Money: Diverging Diamond Interchanges

Highway intersections can cause congestion and are dangerous for through traffic and vehicles turning to access or exit a highway. To improve traffic flow and reduce incidents in these areas, FHWA transportation engineers designed diverging diamond interchanges (DDI). FHWA also commissioned a research study to evaluate DDI installations to better understand the operational efficiency and safety of the design, and tested the design in the human factors laboratory at TFHRC.

The DDI design (see illustration to the right) moves through traffic and left-turning vehicles to the left side of the road at highway intersections. This configuration reduces the number of potential conflict points in an intersection. Conflict points are the point at which a roadway user can cross, merge, or diverge with another roadway user. Reducing the number of conflict points will lead to safer intersections for motorists, pedestrians, and bicyclists.

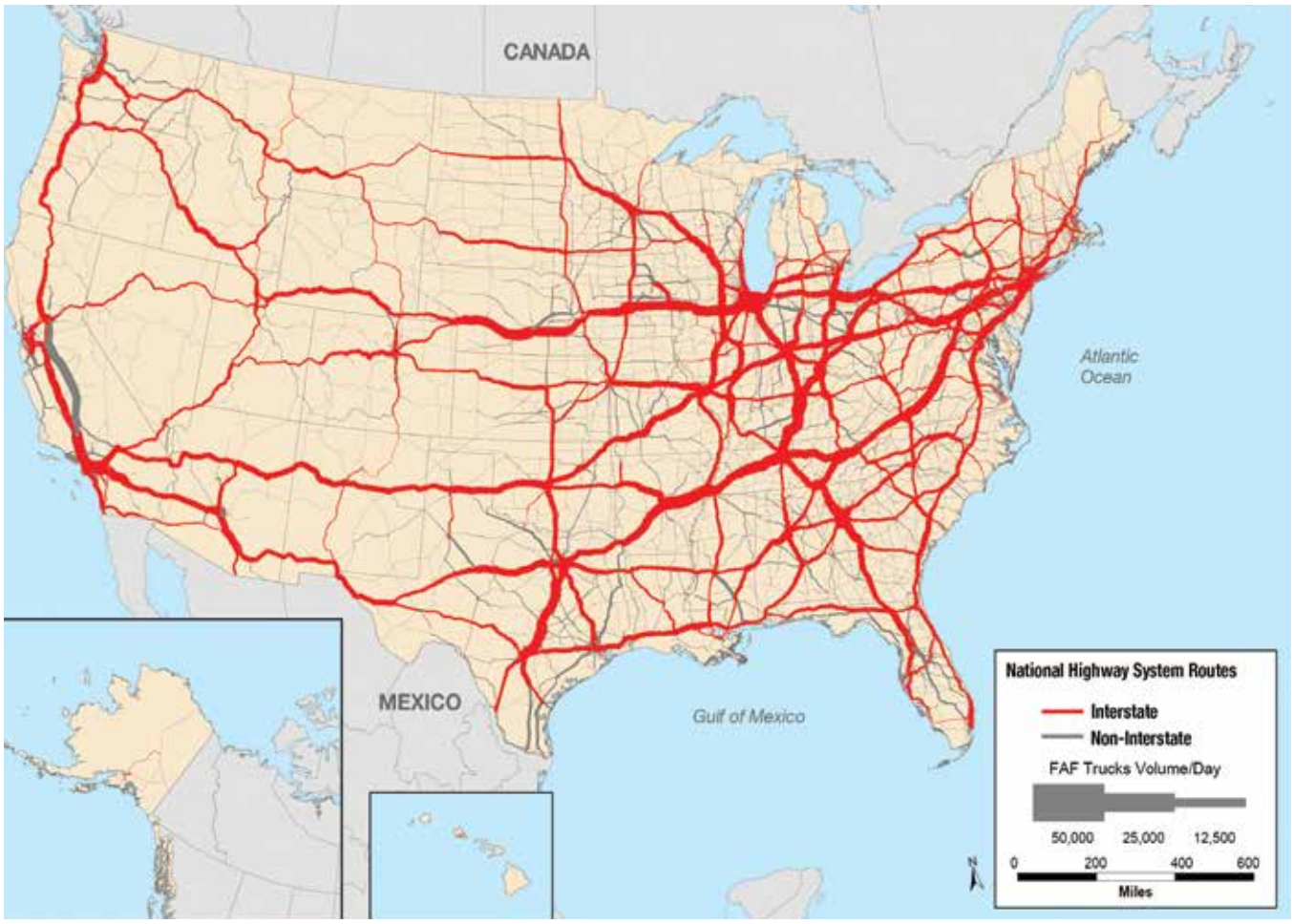
The first DDI in the U.S. was completed in June 2009 at I-44 and MO 13 in Springfield, Missouri. Historically, this interchange had mile-long traffic backups and serious left-turn crashes. When the DDI was completed it eliminated rush hour congestion, proving the validity and effectiveness of the design. Installing a DDI costs roughly 60 percent less than conventional designs and can be completed in 6 months, rather than the typical 18-month period using traditional construction techniques.[16] Based on the proven success of the Springfield DDI, more than 30 DDIs interchanges have been built since 2009. The State of New York saved $4.9 million and reduced total construction time in half by using a DDI rather than the partial cloverleaf configuration alternative, Colorado and the city of Grand Junction doubled the capacity for left turns and saved 70 percent in construction costs over other alternatives for the DDI at I-70 and U.S. 6/50.

Diverging diamond interchanges reduce pedestrian conflicts at busy intersections near freeway ramps. (Source: Missouri DOT)

FHWA continues to conduct research to evaluate the operational and safety impacts of DDIs, identifying strategies to improve safety and accommodate pedestrians and bicyclists who travel along the same roads and highways.

Improving the Freight Network for Economic Growth and Commerce

The volume of freight on the Nation's highways has grown dramatically while shipping methods and materials have also changed. Freight professionals need accurate, current, and comprehensive information to effectively plan for goods movement. States and localities need information to perform economic analyses about major trading partners and the volumes and sources of traffic coming to their jurisdictions.



Long-haul freight traffic in the U.S. is concentrated along major routes between population centers, ports, border crossings, and other major activity hubs. (Image source: FHWA)

An important aspect of enhancing system performance is supporting efficient movement of freight. FHWA developed the Freight Analysis Framework (FAF), an inventory that integrates data from several sources to create a comprehensive picture of freight movement for all modes of transportation, within and between States and major metropolitan areas. FAF also provides a tool that tabulates shipping data by mode and commodity to help decisionmakers manage national freight policy. Now freight analysts and planners can use FAF to better understand complex freight movements. By combining FAF estimates with other data and models they can examine relationships and make cost-effective decisions that improve freight flows and safety; reduce environmental impacts; promote economic activity; and support better integration of freight into transportation system operations.

Fostering Better Transportation Decisions through Better Data

FHWA is also enhancing system performance by promoting the efficient, systematic, and comprehensive collection and utilization of national transportation data to improve highway management and investment decisions. National transportation data provide a breadth of systematic and related information on transportation systems, including temporal, geospatial, behavioral, and socioeconomic aspects. While parameters such as vehicle miles traveled (VMT), fuel efficiency, fuel consumption, population, aging, immigration, and greenhouse gas emissions are interlinked, such critical relationships are often poorly understood.

FHWA is conducting research to develop national specifications for multiple transportation datasets,

including vehicle classification; roadway functional classification; highway performance and monitoring; traffic monitoring; and household travel surveys. These efforts are expected to increase the effectiveness of agencies' data collection and analysis efforts resulting in better consistency among datasets and improved data compatibility among government agencies and the private sector.

Recent advancements in modeling, statistical analysis, and computing speed have enabled more detailed analysis of the interrelationships among these datasets. FHWA seeks to apply advancements to national transportation data to help answer questions about the extent of demand for travel and how and why people travel. A greater understanding of the relationships between various data and parameters can help the transportation community devise effective strategies, programs, and policies to anticipate and meet the public demand for transportation, and ensure a higher-performing system now and into the future. The research paper *Exploring the Relationship between Travel Demand and Economic Growth*[17] helps States understand the relationship between travel demand and economic growth, examining if shifts in automotive and freight travel to other transportation modes would have any impact on the economy. The research paper found that there is no basis in current literature to suggest that efforts to increase environmental sustainability in transportation over the short term would require or depend on reducing VMT. In addition, no strong evidence exists to argue that policies enacted by States or MPOs to reduce VMT will negatively impact economic growth.

Making it Last Longer: Getting the Most Out of Existing Roadways

With constrained space and budgets, it is more challenging than ever for transportation agencies to gain funding and approval for projects to add capacity, or additional lane-miles, to existing highway systems. Therefore, transportation stakeholders need data and tools to maximize the performance of existing infrastructure by effectively planning for and reducing congestion to move more vehicles. Other stakeholders, such as freight professionals, also need tools to effectively plan for expanding travel demand on the Nation's roadways. FHWA's research activities help meet the challenge of enhancing system performance by providing standardized measurement and data-driven solutions to help the transportation community make important decisions about current operations and future system needs.

For More Information

The following Web sites are provided for additional information, and further highlight the transportation challenges and FHWA activities discussed above.

Driving the DDI at American Fork Main Street YouTube Video: https://www.youtube.com/watch?v=LqE1Z77ccwQ.

FHWA Freight Analysis Framework: http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm.

FHWA Office of Highway Policy Information: http://www.fhwa.dot.gov/policyinformation/pubs/pubsandprods.cfm.

Final Report – *Exploring the Relationship between Travel Demand and Economic Growth:* http://www.fhwa.dot.gov/policy/otps/pubs/vmt_gdp/vmt_gdp.pdf.

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16. Bared, Joe and Saiko, Don. (November/December 2010). "The Double Crossover Diamond." *Public Roads.*

17. Federal Highway Administration (2012). *Exploring the Relationship between Travel Demand and Economic Growth.* Washington, DC. Accessed online: February 18, 2015. (http://www.fhwa.dot.gov/policy/otps/pubs/vmt_gdp/vmt_gdp.pdf)

Promoting Environmental Sustainability

The benefits of environmentally friendly transportation networks extend beyond the highway system.

Surface transportation significantly impacts the environment. Motor vehicles are responsible for 23 percent of greenhouse gas emissions in the U.S.,[18] and while essential to supporting mobility and economic growth, traditional highway designs sometimes disrupt critical wildlife habitats. Each year, deer-to-vehicle collisions alone lead to approximately 200 human deaths and $1.1 billion in property damage.[19]

FHWA is a leader in developing new technologies and improved practices that minimize negative impacts on people, the environment, and natural resources. FHWA provides tools, technical assistance, proven processes, and data so State and local agencies can perform effective environmental planning. FHWA also supports transportation agencies' efforts to protect natural spaces and resources that are vital to the health of the Nation's wildlife.

Examples of FHWA research and innovation delivery activities:

- Promoting Roadside Revegetation: An Integrated Approach to Establishing Native Plants
- Using Renewable, Reusable, and Recycled Materials to Achieve a More Durable Highway Infrastructure
- Developing Innovative Tools to Assess Environmental Impacts
- Integrating Sustainability into Transportation Projects

Above: Workers use a high-pressure jet wash and truck-mounted vacuum to remove debris from existing pipes as part of preparations for the FHWA-supported culvert reconstruction project conducted by Montana DOT using trenchless technologies. Half of the corrugated steel pipe culverts would be lined (sliplined) with high-density polyethylene pipe and half would be lined with cured-in-place pipe. Below: FHWA supported a new construction project with Georgia DOT. A solar-powered trailer and traffic sensor were used as part of the system. (Images: FHWA)

Research Activities

Examples of FHWA R&T that support the environment include finding effective ways to grow native plants following a highway construction project, establishing policy that supports the use of recycled materials in construction, and developing online tools to integrate environmental considerations into standard business practices.

Promoting Roadside Revegetation: An Integrated Approach to Establishing Native Plants

Today, most road projects involve modifications to existing roads rather than new construction. Execution of such projects in a safe and effective way while maintaining ecological health is a critical component of success. Modifying roads or updating them section by section also presents a tremendous opportunity to remedy the oversights of the past, mitigate environmental impacts, and improve the health of affected ecosystems. Making the environment an important consideration for transportation improvements requires standardized guidance and a framework for collaboration across and among stakeholders.

FHWA streamlines federal land management and Tribal processes to improve timeliness and effectiveness of program and project delivery. Through its Coordinated Technology Implementation Program, FHWA worked with the U.S. Forest Service to develop a comprehensive roadside revegetation technical guide, which offers an integrated approach to facilitate the successful establishment of native plants along roadsides and other areas of disturbance associated with road modifications.

The guide introduces a comprehensive process of initiating, planning, implementing, and monitoring a roadside revegetation project with native plants. The partnership also resulted in a Web site, at http://www.nativerevegetation.org/, which contains integrated and interlinked modules dedicated to explaining the art and science of roadside revegetation.

Currently, FHWA's Western Federal Lands Highway Division uses native vegetation in all of its construction projects. Both the National Park Service and the U.S. Forest Service have vigorous revegetation programs in place. Glacier National Park operates its own nursery to grow native plants for revegetation of disturbed areas. In addition, Oregon, Washington, and California State DOTs use native plants in many of their highway construction projects.

Vegetation Management: An Ecoregional Approach is a recent example of FHWA's commitment to cost-effective sustainability. FHWA encourages State land managers to adopt an ecoregional approach to better manage roadside vegetation, and the guide provides practical advice to help them accomplish this. The examples and instructions found in the guide make clear that, by using native plants in highway projects, States can save fuel and other maintenance costs while reducing their environmental impact. State DOTs have received copies of the guidebook, and an e-book version will be available in 2015.

Using Renewable, Reusable, and Recycled Materials to Achieve a More Durable Highway Infrastructure

FHWA is advancing the effective use of renewable, reusable, and recycled materials to reduce the cost of transportation projects and ease the effects of transportation construction on the environment. For example, use of reclaimed asphalt pavement (RAP) in pavement mixtures has been turning what might otherwise be sent to a landfill as waste material into a resource for more than 30 years. However, currently available guidance has proven inadequate to ensure that pavements built with RAP will be durable. FHWA has built and is currently testing full-scale pavements that contain specific levels of RAP to assess its performance. When completed, this research will deliver guidance to help highway agencies and their contractors achieve durable pavements when using RAP.

Building on the research findings from FHWA and the knowledge-sharing provided by FHWA's Sustainable Pavement Technical Working Group, numerous States are currently using recycled construction materials to save on costs and free up funds for additional highway construction, maintenance, and repair. For example, using recycled materials is commonplace on New York State Department of Transportation (NYSDOT) projects. Recycled materials allowed directly in the NYSDOT standard specifications include RAP, recycled concrete aggregate, beverage container glass, blast furnace slag, and coal fly ash, among others. Other recycled materials are evaluated on a case-by-case basis. For instance, average RAP in asphalt mixes is estimated to be around 15 to 20 percent and recycled concrete is the predominant granular material used in the metro New York Area. Additionally, when concrete is removed from pavements and structures, any reinforcing is typically removed and recycled, and the concrete often becomes fill material somewhere else on the project to flatten slopes and is occasionally used as filter material. The Department's sustainability program, GreenLITES, has also contributed to the increased use of recycled and reused materials and greatly contributes to NYSDOT's supporting a sustainable society.

Developing Innovative Tools to Assess Environmental Impacts

The National Environmental Policy Act of 1969 (NEPA) requires both the assessment of environmental impacts of federal activities and the planning of any needed mitigation to lessen or eliminate damage from construction activities. As part of its commitment to NEPA, FHWA requires the examination and avoidance of potential impacts to the social and natural environment when considering approval of proposed transportation projects. FHWA also incorporates into this process a NEPA-mandated interdisciplinary approach in planning and decisionmaking for any action that adversely impacts the environment. Transportation agencies need tools that facilitate collaboration across transportation, regulatory, and special-interest organizations to plan and deliver projects as quickly and efficiently as possible.

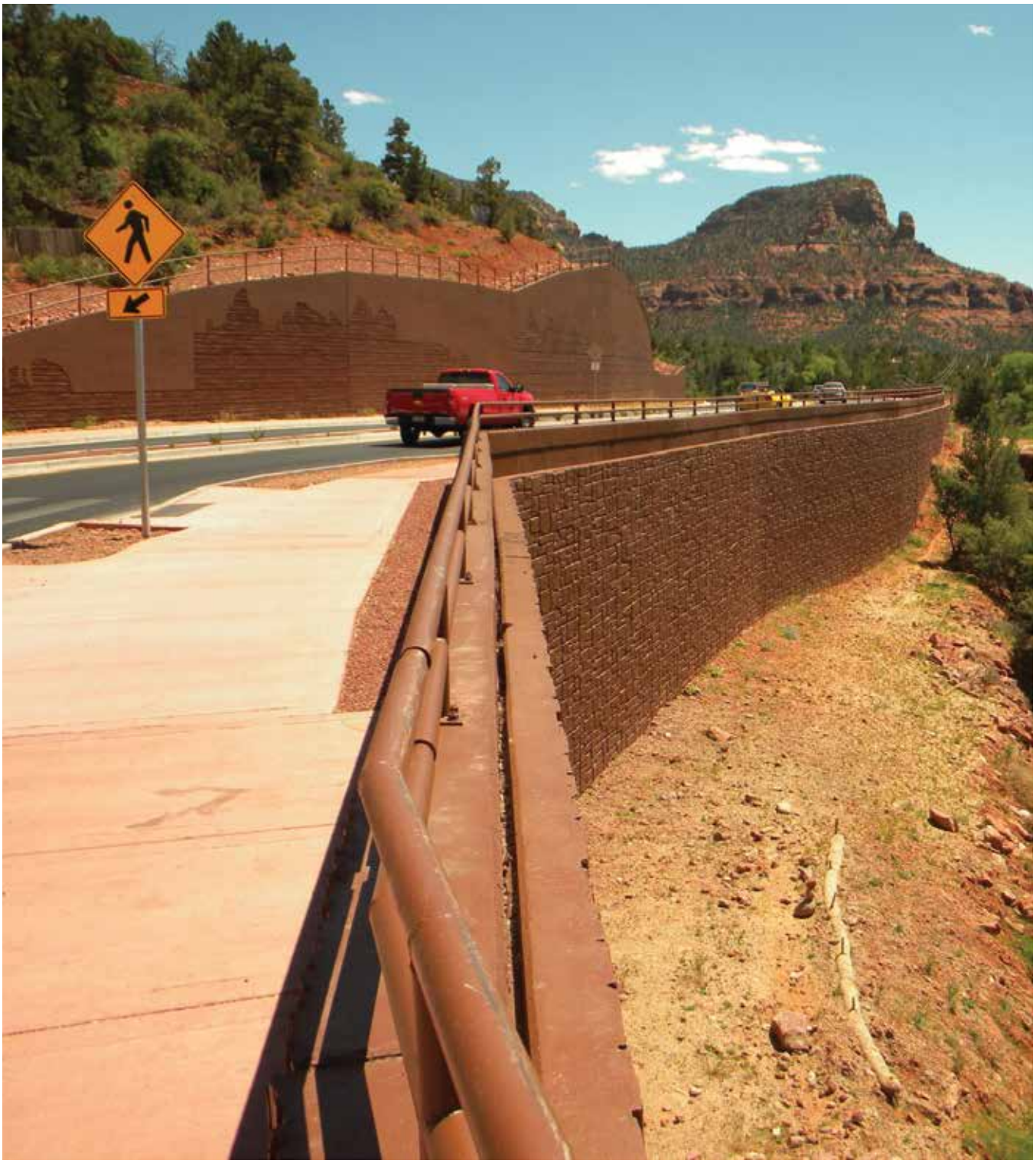
As part of its objective to promote more informed transportation decisionmaking, FHWA developed an online tool called e-NEPA to help practitioners streamline the NEPA process. e-NEPA is a real-time electronic collaboration tool that allows State DOTs to share documents, track comments, schedule tasks with participating agencies, and perform concurrent reviews of their environmental impact statements and environmental assessments. Currently, States are piloting the tool on a number of environmental impact statement and environmental assessment projects to determine impacts and success factors.

Integrating Sustainability into Transportation Projects

As environmental impacts play an increasingly important role in highway planning, transportation agencies need tools to integrate environmental considerations into their policies, processes, procedures, practices, and projects.

As part of its commitment to promote integrated planning that improves transportation safety and addresses environmental, social, and economic needs, FHWA developed the Infrastructure Voluntary Evaluation Sustainability Tool (INVEST). Available at www.sustainablehighways.org, INVEST is being used by 29 agencies in 25 States and Washington, DC including DOTs, MPOs, councils of government, and public works departments. Other partners use INVEST to evaluate and integrate sustainability into their programs and projects.

The FHWA Eastern Federal Lands Highway Division (EFL) used concepts from INVEST's Project Development (PD) module in their Construction Winter Training Program. The goal of this training was to increase awareness and facilitate greater discussion about sustainability, and to further integrate sustainability considerations into project



Newly reconstructed and environmentally sensitive business-tourist corridor with new vehicle lanes, pedestrian pathways, and structural retaining walls, developed as part of an FHWA project. (Image source: FHWA)

planning, design, and construction. Using INVEST, EFL found that the Mulligan Road project, located in Fairfax Country, Virginia, excelled in criteria related to context sensitivity, pedestrian and bicycle access, ecological connectivity, long-life pavement, environmental training, and construction quality control. Other criteria identified as potential areas for improvement with relatively low additional effort included site vegetation, reducing and reusing materials, and construction waste management.

INVEST has helped show EFL staff the benefits of integrating sustainable practices.

The Illinois Tollway Authority used INVEST to complete an 18-project retrospective evaluation that will set baselines and minimize environmental impacts of new roadway construction by reusing and recycling materials, reducing energy costs, and measuring sustainability of practices. Illinois Tollway will incorporate the INVEST tool into the planning, development, and operations lifecycle of the 15-year, $12 billion Move Illinois Program. INVEST will allow the agency to identify institutional and other barriers that may prevent it from implementing sustainable practices during the construction phase.

Similarly, Ohio DOT used the INVEST PD module during the reconstruction of the Cleveland Innerbelt Bridge/I-90, also known as the George V. Voinovich Bridge. It was critical for Ohio DOT to achieve sustainability for this high-priority project, and the agency focused on major savings in fuel, steel, water, and waste. INVEST was so successful in helping Ohio DOT realize these savings in Phase 1 of the project, it was used to ensure contractor performance during Phase 2. By requiring INVEST as part of the Request for Proposals for the design-build contract, Ohio DOT gave contract bidders a strong incentive to include sustainability practices as part of their proposals while also keeping costs competitive.

The Massachusetts DOT used the INVEST PD module to evaluate the Casey Arborway Project, which could replace a 1950s-era elevated highway with an at-grade roadway with strong pedestrian connectivity. Arizona DOT (ADOT) is using INVEST's PD module to conduct an assessment of its statewide roundabout program. Particular criteria that Arizona plans to examine further include: green infrastructure and low-impact development, bike and pedestrian mobility, and context-sensitive solutions. Arizona found that INVEST helped ADOT further internal lines of communication, sparking new types of discussion and collaboration.

Leading the Way to More Environmentally Sustainable Highways

The safety, long-term economic viability, and continued operation of the highway system and well-being of its users are affected by environmental factors. FHWA R&T focuses on environmental sustainability as a key challenge because motor vehicles are a significant source of greenhouse gas emissions and roadway construction can adversely affect wildlife habitats.

Environmental sustainability is based on the principle that everything needed for peoples' survival and well-being depends, either directly or indirectly, on the natural environment. Sustainability creates and maintains the conditions under which humans and the natural world can exist in productive harmony, allowing the fulfillment of social, economic, and other requirements of present and future generations. Sustainability is essential for making sure the Nation has and will continue to have water, raw materials, and resources to protect human health and the environment.[20] FHWA's strategic approach to R&T comprehensively addresses environmental sustainability, and seeks new ways to increase efficiency and collaboration while decreasing impacts to the natural environment and wildlife.

For More Information

The following Web sites are provided for additional information, and further highlight the transportation challenges and FHWA activities discussed above.

Road Revegetation: An Integrated Approach to Establishing Native Plants: http://www.nativerevegetation.org/.

FHWA Recycling Policy: http://www.fhwa.dot.gov/pavement/recycling/.

FHWA Environmental Review Toolkit: http://www.environment.fhwa.dot.gov/index.asp.

FHWA INVEST Version 1.0: https://www.sustainablehighways.org/.

18. Federal Highway Administration (2007). *Roadside Revegetation: An Integrated Approach to Establishing Native Plants.* Washington, DC. Accessed online: February 18, 2015. (https://www.wfl.fhwa.dot.gov/programs/td/publications/documents/reveg-documents/roadside-revegetation-manual.pdf)

19. Mastro, Lauren L.; Conover, Michael R.; and Frey, S. Nicole. (2008). "Deer–Vehicle Collision Prevention Techniques." *Human–Wildlife Interactions.*

20. United States Environmental Protection Agency (2015). "What is Sustainability?" (Web page) Washington, DC. Accessed online: February 18, 2015. (http://www.epa.gov/sustainability/basicinfo.htm)

Preparing for the Future

Looking beyond today's challenges to anticipate the emerging issues of tomorrow.

FHWA is the agency within the USDOT that supports State and local governments in the design, construction, and maintenance of the Nation's highway system (Federal Aid Highway Program) and various Federal and Tribal-owned lands. Through financial and technical assistance to State and local governments, FHWA is responsible for ensuring that America's roads and highways continue to be among the safest and most technologically sound in the world.

The challenges facing transportation agencies are continuously changing as technology, demographics, the environment, and the economy evolve. FHWA forecasts transportation change by examining evolving passenger and freight transportation needs against a range of scenarios. FHWA assists the transportation workforce by identifying emerging trends such as innovative finance and program delivery methods, and new techniques for long-range policy planning. This is accomplished, in part, by building strong relationships with researchers to more quickly track and identify the benefits of new scientific discoveries.

Examples of FHWA research and innovation delivery activities:

- Creating Productive Roadways—Developing an Advanced Energy Production, Storage, and Distribution System
- Developing Connected Vehicle Technology to Improve Safety and Mobility
- Training Transportation Decisionmakers and Practitioners
- Studying the Next Generation of Travelers
- Finding New Ways to Fund Transportation Projects

Above: Pre-cast concrete deck panels are aligned on top of steel bridge girders as part of an FHWA Highways for LIFE project implemented by Minnesota DOT to replace a deteriorated bridge using ABC techniques. Below: Solar-powered lamps are installed along a pedestrian walkway in proximity to a busy highway. (Image source: FHWA)

Research Activities

From developing infrastructure that will help meet future energy demands to improving safety and mobility through connected vehicle technology, highway finance, and taxes—FHWA research anticipates tomorrow's highway challenges through industry study and engagement.

Creating Productive Roadways—Developing an Advanced Energy Production, Storage, and Distribution System

Imagine using the public right-of-way as a source of energy. The EAR Program has done just that, funding the Roadway Wind/Solar Hybrid Power Generation and Distribution System (RHPS). Created in partnership with the University of Nebraska, the project is developing an intelligent power system that may provide cost-effective, efficient, and reliable renewable electric power production, storage, and distribution. RHPS has the potential to reduce highway maintenance and operating costs, and provide backup for traffic control systems during power outages, thereby improving operational efficiency and reliability.

RHPS has at its core a wind and solar hybrid power system that can attach to existing structures for traffic signals, roadway lighting, and overhead road signs. Each signal will feature solar panels and a wind-turbine generator to produce power for onward distribution through the electric power grid. A power-management system will be developed to manage production, storage, distribution, and consumption of energy based on demand interacting with roadway communication and networking infrastructure.

The project represents significant technological advancement in renewable energy and production, storage, and distribution. By utilizing existing infrastructure to produce and distribute power, RHPS is expected to have an impact on the development of next-generation smart electric power grids. RHPS will significantly reduce the overall power needed to operate roadway systems, and create a more efficient network. It will also offer a source of backup power for the transportation system, thus reducing the risk of blackouts.

At a field test site in Lincoln, Nebraska, RHPS equipment was installed on 1 of 4 of the traffic signals in an intersection, and the lifecycle savings at the intersection was estimated at $15,000 over 20 years with a break-even time of roughly 10 years.

FHWA is also researching ways to harvest piezoelectric energy through pavement applications in the public right-of-way that will capture the excess energy lost in pavement deformation and vibration created by cars, trucks, and other vehicles on the Nation's highways. Currently, FHWA is studying the feasibility of piezoelectric generation technologies as an energy harvesting option through laboratory testing, analytical modeling, and field testing. Results of this work will be evaluated to determine the appropriate applications for this technology.

Developing Connected Vehicle Technology to Improve Safety and Mobility

In an effort to improve safety and efficiency for freeway merging, FHWA funded a project to develop and evaluate three algorithms related to dynamic lane control, gap-responsive metering, and merge control using connected vehicle communications. Researchers used an enhanced simulation environment to evaluate the algorithms' safety and efficiency impacts under different scenarios of vehicles with and without vehicle-to-vehicle and vehicle-to-infrastructure communication equipment.

The freeway merge assistance algorithms are part of a larger network of USDOT initiatives. The goal of the initiatives is to develop connected vehicle technology that improves the safety, mobility, and sustainability of roadways. FHWA R&T also supports this important effort in areas of safety and the development of connected vehicle research.

Training Transportation Decisionmakers and Practitioners

Recognizing that tomorrow's innovative project designs come from a knowledgeable and confident workforce, FHWA created the IPD (Innovative Program Delivery) Academy. The IPD Academy provides decisionmakers and practitioners with the tools and knowledge needed to explore and implement innovative strategies to deliver transportation programs and projects.

Launched in 2009, the IPD Academy provides a comprehensive selection of courses and curricula, including webinars, workshops, and expert assistance. The IPD Academy helps USDOT's professional staff integrate innovative delivery strategies into their specific disciplines and focus areas. Attendees learn strategies for overcoming resource constraints, addressing energy and environmental considerations, and promoting efficiencies in program delivery. The IPD Academy also delivers training to professionals at State and local transportation agencies. The IPD Academy has delivered more than 140 webinars registering 27,000 participants representing all 50 States, the District of Columbia, and Puerto Rico. Webinar participants have included financial managers and specialists, major project engineers, Federal Transit Administration regional offices, the Federal Railroad Administration, and industry experts in freight, legal, planning, and civil rights.

Studying the Next Generation of Travelers

What will personal travel look like in the future and how will it influence system demand down the road? As part of a strategic objective to evaluate and analyze current and emerging issues that will affect surface transportation, the FHWA Transportation Futures Team finalized a report that examines trends related to the travel behavior of young people between the ages of 15 and 26. This information will be used to develop policy recommendations. The desired outcome will be improved travel forecasts of demand, vehicle usage, and how new transportation technologies impact

Jeremy Walcott, P.E., gives an overview of a FHWA Highways for LIFE construction project at a showcase held at the Florida DOT District 5 office. (Image source: FHWA)

personal travel. The team understands that personal travel will be influenced by a combination of various events, demographic and socioeconomic factors, generational social norms, and adaptation of people to new technologies and travel options. This comprehensive research incorporates a broad spectrum of perspectives.

The work completed under the travel behavior study provides both a quantitative and qualitative evaluation of current and emerging travel shifts by generation. Of particular interest are the impacts of new technologies and social trends that may influence mode choice, trip making, trip planning, and overall perceptions of vehicle travel among youth in the U.S. The results of the analyses will be used to develop profiles of the next generation of travelers, and will be considered in future travel trend forecasts and travel scenario development. The information presented is ultimately intended to be used as a guide in the development of current and future transportation policies regarding personal travel.

Finding New Ways to Fund Transportation Projects

Despite record levels of investment in surface transportation infrastructure in recent years, traditional funding sources have not kept pace with the investment demands of an aging and increasingly complex U.S. transportation system. Transportation officials at all levels of government will continue to seek innovative ways to fund improvements to the Nation's transportation system.

For almost two decades, the federal government has responded to this investment gap by providing new techniques that complement and enhance existing grant reimbursement programs. By providing

FHWA's Highways for LIFE program supported the Missouri DOT's construction of the Christopher Bond Bridge through an innovative design build procurement process. The bridge foundations were designed and constructed using cost-effective technical engineering solutions that led to significant savings in time and money. (Image source: FHWA)

FHWA's Highways for LIFE program supported the placement of the pier table on the deck of the Christopher Bond Bridge through an innovative design build procurement process, providing cost savings and flexibility in the bridge construction schedule. (Image source: FHWA)

individualized tools and technical assistance, FHWA helps State and local agencies assess the applicability of available financing options for complex projects so that they can build the highways and bridges necessary to keep pace with a growing Nation.

FHWA's Project Finance Primer describes those techniques and provides examples of their application by State and local partners. The Primer will continue to evolve and lay the groundwork for the identification of additional innovative strategies for financing surface transportation investments into the future.

The Ohio River Bridges project, a bi-State collaboration between Kentucky and Indiana, is one example of how State and local partners can use innovative financing strategies to complete complex highway infrastructure projects. Developed via a joint planning effort, the two States approached their respective bridge projects from different financial perspectives. Kentucky chose to finance its toll bridge using bonds, including Grant Anticipation Revenue Vehicles, while Indiana committed to make availability payments to a long-term concessionaire that obtained financing in part with Private Activity Bonds. When completed in 2018, the two new bridges over the Ohio River will link Louisville and southern Indiana. The new bridges are expected to improve traffic flow, reduce congestion, improve safety, and

enhance transit service. Innovative financing accelerated project delivery, evenly distributed project costs, provided additional financing options, and leveraged federal grant funds using private-sector equity and expertise.

For more information on the project financing, please visit FHWA's project finance Web site, which focuses on alternative financing mechanisms. In addition, the IPD Web site has information detailing Public-Private Partnerships, and the Transportation Infrastructure Finance and Innovation Act, which provides credit assistance for significant projects.

Anticipating Tomorrow's Highway Challenges

FHWA R&T is transforming today's big ideas into the innovations to meet future transportation challenges, ensuring that they are incorporated into the construction, maintenance, and operation of the Nation's highway system. FHWA's strategic approach to innovation means that preparing for the future is an essential part of the Agency's efforts.

For More Information

The following Web sites are provided for additional information, and further highlight the transportation challenges and FHWA activities discussed above.

EAR Program Fact Sheet—Creating Productive Roadways: http://www.fhwa.dot.gov/advancedresearch/pubs/12063/index.cfm.

Fact Sheet—Efficient and Safe Merging Solutions—Advanced Freeway Merge Assistance: Harnessing the Potential of Connected Vehicles: http://www.fhwa.dot.gov/advancedresearch/pubs/14045/index.cfm.

IPD Academy: An Introduction: http://www.fhwa.dot.gov/ipd/pdfs/fact_sheets/h_pdi_academy_1_19_12.pdf.

FHWA Transportation Futures—Future Uses of Highway Rights of Way: http://www.fhwa.dot.gov/policy/otps/transfutures.cfm.

FHWA Project Finance Primer 2010: http://www.fhwa.dot.gov/ipd/finance/resources/general/default.aspx.

Research Moves the Nation Forward

Conclusion

To continue economic growth and serve a growing population, the U.S. must invest not only in its transportation system but also in research to improve safety, protect the environment, reduce congestion on crowded roadways, and provide alternative methods of moving people and goods.

Laboratory assessment and research are critical pieces of FHWA's work in ensuring that the Nation's roadways and infrastructure are safe, sustainable, and cost-effective in the years ahead. (Image source: FHWA)

The results and benefits of FHWA's research efforts can be seen across the country in many of the projects discussed in this report. Within FHWA, hundreds of research projects are underway to develop innovations and solve the country's pressing transportation problems. Because transportation comprises many disciplines, from human factors to structural impacts to environmental and safety impacts, an extensive depth and breadth of knowledge is necessary to address the challenges facing our transportation system.

FHWA professionals are known worldwide for their expertise, and they collaborate with national and international transportation agencies and communities to conduct and review research projects and technology transfer initiatives within a highly collaborative system. Because of the complexity of the system, setting the right research agenda is critical to making an impact across the entire transportation system. As public expectations change and demand on the highway system continues to increase, FHWA's R&T leadership will play a critical role in anticipating future challenges and providing the highway community with innovations to maintain and improve the safety and mobility of the highway system and economic prosperity of the Nation.

For more information or to provide feedback, please visit the FHWA research Web site at www.fhwa.dot.gov/research.

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