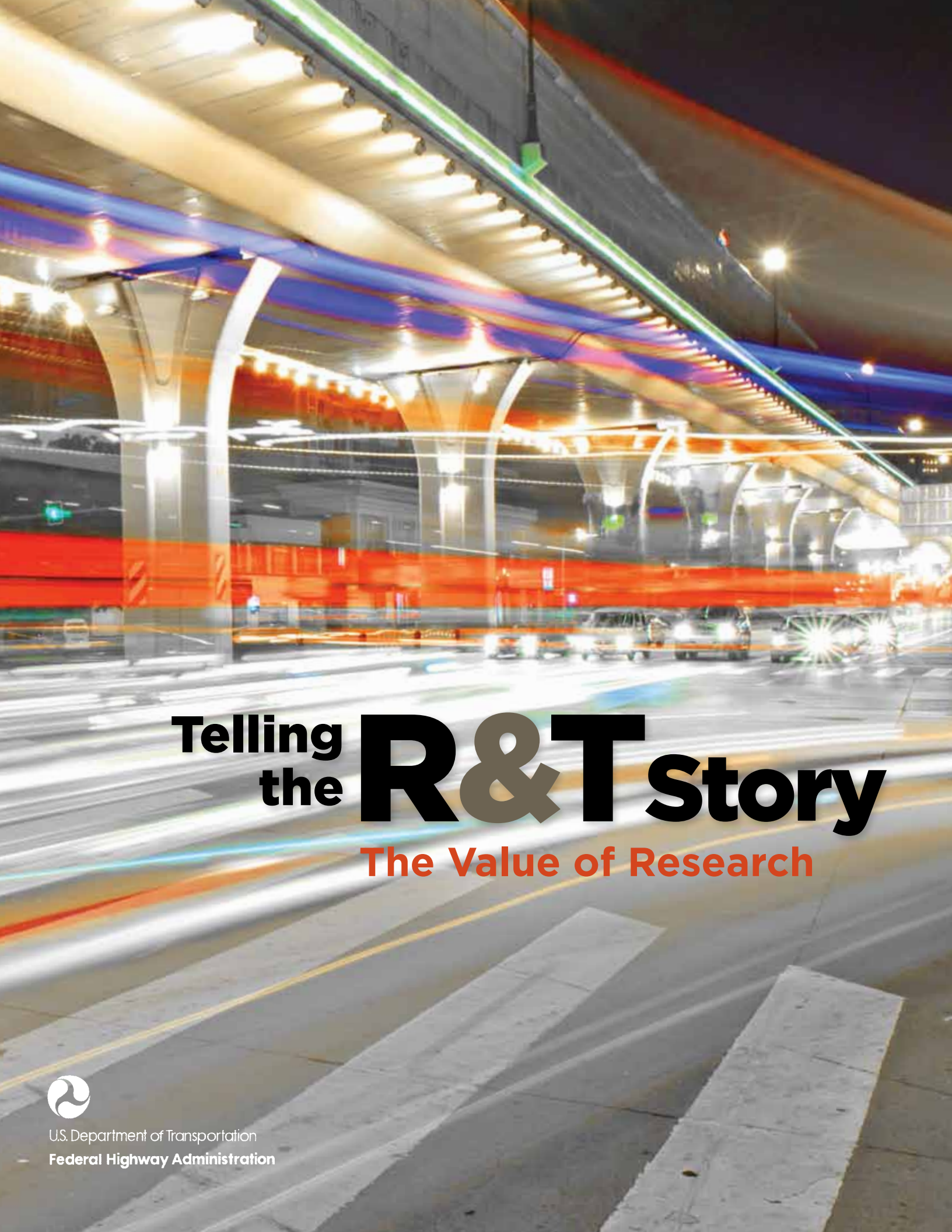

Telling the R&T Story

The Value of Research

U.S. Department of Transportation
Federal Highway Administration

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Safer, smarter, more cost-effective, and more sustainable. Though sometimes unseen, the technologies and products developed through the Federal Highway Administration's (FHWA) research and technology (R&T) programs are improving the Nation's roads and bridges coast to coast, saving lives, supporting the economy, and reducing congestion.

Whether reflected in the more durable surfaces of the roads and bridges we travel on regularly, better designed intersections, smarter traffic lights that are more responsive to traffic flow, or the surrounding businesses and communities supported by a strong highway system, transportation R&T is making a difference every day. These efforts are being advanced through FHWA's Every Day Counts initiative, which is designed to identify and deploy proven, ready-to-go innovation aimed at shortening project delivery, enhancing roadway safety, and protecting the environment. Through partnerships with State and local transportation agencies, industry, and academia, we are also creating a better future. Advanced research is sponsoring long-term projects with a high payoff potential, while sustainability initiatives aim to build highways and structures that reduce impacts on the environment and consumption of natural resources. FHWA also provides leadership in assessing the impact of new technologies, obtaining valuable data that will help guide future research efforts.

Leading the way on high priority research in everything from pavement materials to the human factors that contribute to safer roads, FHWA's R&T programs are developing the solutions that will define tomorrow's highway system. In the many innovations and groundbreaking technologies described here, learn about the value these R&T initiatives are contributing nationwide and get a glimpse of an even brighter transportation future.

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The R&T Innovation Cycle and FHWA's Leadership Role

Working with its partners in the public and private sectors, academia, industry, and the international community, the Federal Highway Administration (FHWA) plays a vital leadership role in developing and implementing a coordinated highway research and technology (R&T) agenda that addresses national needs, meets future demands, and maximizes the strengths of all research entities. This R&T agenda is stakeholder driven, with partners engaged throughout the entire process, from agenda setting and planning, through the research, technology development, and innovation deployment phases, to the implementation and assessment stages.

The technological advances resulting from the FHWA R&T agenda come at a crucial time. America's $1.75 trillion highway network is the backbone of the country, providing critical just-in-time freight services for industry; carrying individuals to jobs, schools, and recreational activities; and serving a vital national defense role. This network is aging, however, with many roadways and bridges now having outlived their original design life and in need of rehabilitation or reconstruction. Transportation agencies must plan these multiplying projects while contending with increased congestion, tighter budgets, and reductions in staffing, including the loss through retirement and attrition of experienced engineering and construction personnel. At the same time, the overall highway program is more complex, with agencies juggling environmental sustainability and community considerations, urban planning goals, and the increased operational requirements of older roadways carrying more vehicles, among other responsibilities.

Technology and innovations built the national highway network, and technology is now the key to overcoming today's complex challenges and sustaining that network, so that current and future generations can enjoy the freedom that comes with mobility, as well as the safety of a well-maintained system. This technology can take the form of high-performance and long-lasting materials, so that the 50-year pavement or the 100-year bridge becomes a reality. It can also mean strategies for accelerating construction, so that projects are completed faster and with less disruption for motorists. And it can mean safety improvements, so that fewer vehicles run off the road or are involved in intersection crashes.

To move these innovations from idea to reality, national leadership and innovative strategies are more important than ever. As the Transportation Research Board (TRB) noted in the 2001 *Federal Role in Highway Research and Technology Special Report 261,* "Only the federal government has the resources to undertake and sustain high-risk—but potentially high payoff—research, and only the federal government has the incentives to invest in long-term, fundamental research." Now is the time for both effective investment and new solutions.

To achieve these solutions—and ensure that they are put into practice—FHWA leads in developing and implementing a nationally coordinated highway R&T agenda. The components of this agenda include:

- *Highway Research and Development*. FHWA conducts research in the areas of safety, infrastructure preservation and improvements, planning and environment, operations, policy, and next generation technology.
- *Technology and Innovation Deployment*. When the new technologies and products that result from research, whether conducted or sponsored by FHWA or by other participants in the nationally coordinated R&T agenda, are ready for implementation, FHWA works to accelerate the

adoption of high-payoff innovations. The FHWA Resource Center and the Agency's State Division offices play key roles in the deployment process.

- *Training and Education*. FHWA concentrates on training the current and future transportation workforce through such venues as the National Highway Institute (NHI) and the Local Technical Assistance Program.

The components of FHWA's R&T program—Highway Research and Development, Technology and Innovation Deployment, and Training and Education—are intended to be integrated, continuous processes that work together to move technologies from the research phase to the development, implementation, and impact assessment phases. Historically, FHWA's commitment to highway research has changed the way roads and bridges are designed, constructed, operated, and maintained across the country. Its R&T program continues that legacy today.

As FHWA sponsors, conducts, and guides highway research, the involvement of stakeholders and the public is integral to R&T development and deployment activities. Stakeholder involvement is vital, for example, to the process of developing FHWA's R&T program plans, which describe key R&T objectives and multi-year plans for research. FHWA also partners with State departments of transportation (DOTs), the American Association of State Highway and Transportation Officials (AASHTO) Research Advisory Committee, and the AASHTO Standing Committee on Research to develop and deploy R&T programs.

The success of new technologies and products developed through FHWA research ultimately depends on their acceptance by States, industry, and other stakeholders. Innovation delivery is another key step in the R&T life cycle. Through demonstration projects, education and training programs, manuals and other publications, and hands-on assistance, FHWA works to support the deployment of new, cost-effective, and high-performing technologies. Deployment efforts are coupled with assessment initiatives, which complete the R&T life cycle by evaluating the impact of new processes and technologies.

FHWA's commitment to highway research has changed the way roads and bridges are designed, constructed, operated, and maintained.

Responding to National Needs

The Value of Research

From improving the durability of the Nation's highways and bridges to designing and building safer roadways to reducing transportation infrastructure's impact on the environment, FHWA's R&T initiatives are meeting today's national needs and exploring next generation solutions. Research is supported by the Agency's R&T funding, as well as Strategic Initiatives funding that was authorized under the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Technical Corrections Act of 2008. FHWA's Strategic Initiatives provide flexible funding for cross-functional research that may cut across program areas. The flexible funds give FHWA the opportunity to direct resources to address strategic needs, advance major goal areas, fill current research gaps, and focus on emerging and anticipated issues.

Recent R&T accomplishments include a diverse range of advancements in technology. These innovations open up a new world of what is possible in transportation today, encompassing sophisticated software programs that can aid in building more sustainable roadways, laboratories that explore the latest in intelligent transportation systems, and pavements and bridges built with advanced materials. FHWA's research also continues to look ahead to the breakthroughs that await tomorrow.

Improving Highway Safety

In 2009, the number of people killed in motor vehicle crashes in the United States dropped to its lowest level since 1950, and the number of people injured declined for the 10th straight year, falling an estimated 5.5 percent from 2008. With more than 33,000 persons killed and 2 million injured in roadway crashes, however, building on these advances and continuing to improve highway safety remains a top priority for all of the Nation's transportation agencies. FHWA researchers conduct investigations that examine drivers, vehicles, and the highway infrastructure, focusing on how to create a safer environment for all roadway users.

The implementation of roundabouts in Iowa and other States is improving intersection safety. Shown here is a roundabout in Coralville, Iowa.

Traffic travels around a roundabout in Garnett, Kansas.

Designing Safer Intersections

FHWA continues to be at the forefront of research into the design and application of roundabouts, which are one-way, circular intersections where traffic flows around a center island. With intersection-related crashes accounting for 47 percent of all crashes in the United States and 21 percent of all traffic fatalities, improving intersection safety is an important priority for FHWA. The results from roundabouts in use to date are significant. A National Cooperative Highway Research Program (NCHRP) Report, *Roundabouts in the United States* (NCHRP Report No. 572), found that the installation of roundabouts led to a 35 percent reduction in total crashes and a 76 percent reduction in crashes causing injuries or fatalities. Other studies have also reported impressive safety benefits. To support the implementation of roundabouts across the country, FHWA published *Roundabouts: An Informational Guide* in 2000. When it was issued, fewer than 100 modern roundabouts existed in the United States. With about 2,000 roundabouts located throughout the country today, TRB released *Roundabouts: An Informational Guide,* Second Edition (NCHRP Report No. 672) in 2010. Jointly funded by FHWA, the report officially updates and supersedes the 2000 Guide. A newly launched FHWA Roundabouts Peer-to-Peer Program, meanwhile, is providing technical assistance to State DOTs and others as they implement the technology. California, Connecticut, Illinois, Massachusetts, and Missouri have received assistance to date. NHI also offers training on "Modern Roundabouts: Intersections Designed for Safety" (Course No. FHWA-NHI-380096).

Sidewalks That Don't Trip You Up

Pavement smoothness is not only vital to building better roadways but a key factor in ensuring that sidewalks and curb ramps are accessible to individuals with disabilities and meet the standards of the Americans with Disabilities Act (ADA). However, the traditional ADA survey process for assessing the condition of sidewalks and curb ramps is time-consuming and does not offer jurisdictions precise data. The Ultra-Light Inertial Profiler (ULIP), an instrumented Segway® developed by FHWA for pavement surface evaluation, offers an accurate and cost-effective solution. FHWA provided technical support as Bellevue, Washington, used the ULIP to conduct an ADA evaluation of existing physical barriers for persons with disabilities. Use of the technology cut

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The SafetyAnalyst software provides state-of-the-art analytical tools that transportation agencies can use as they make decisions about roadway safety improvements, such as installing an overhead flashing beacon to enhance the visibility of intersections.

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Sally Swanson Architects, Inc., used the Ultra-Light Inertial Profiler-ADA (ULIP-ADA™) to conduct an Americans with Disabilities Act (ADA) evaluation of sidewalk running grade, cross slope, and change in level for the City of Clovis, California.

Bellevue's costs from more than $1 million to $285,000 and resulted in more precise data on conditions such as pavement roughness and defects, helping the city to better prioritize its remediation efforts. The cities of San Marcos, Clovis, and San Carlos in California are also using the ULIP for ADA assessment in 2011.

The Right Safety Tool for the Right Job

To make the best decisions about highway safety improvements, transportation agencies need comprehensive data and sophisticated data analysis tools. A survey of State highway agencies, for example, found that improving the data analysis process was the top-ranked need for increasing the effectiveness of safety management. The SafetyAnalyst software provides state-of-the-art analytical tools that transportation agencies can use as they make decisions about site-specific highway safety improvements. These tools, for example, can help agencies identify safety problems at specific sites and then select countermeasures to reduce the frequency and severity of crashes.

Developed through a pooled fund effort by FHWA and participating State agencies, the software is now available from AASHTO. Among the States that participated in the pooled fund was Ohio, which is now integrating SafetyAnalyst into its safety program so that funds can be directed to locations where transportation improvements will have the greatest potential to reduce severe crashes and save lives.

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Safety improvement strategies can also include installing center two-way left-turn lanes on two-lane roads.

SafetyAnalyst is just one of the software tools created through FHWA that supports implementation of the new *Highway Safety Manual* (HSM), which was developed by TRB and released by AASHTO. Deployment of the tools has been supported by flexible, cross-functional research funding. Other available tools include the Interactive Highway Safety Design Model (IHSDM). The IHSDM is a suite of software analysis tools for evaluating the safety and operational effects of geometric design decisions on highways. The software supports decisionmaking in the highway design process by providing estimates of a design's expected safety and operational performance, and checking existing or proposed highway designs against relevant design policies. IHSDM currently includes six evaluation modules: Crash Prediction, Design Consistency, Intersection Review, Policy Review, Traffic Analysis, and Driver/Vehicle. The updated 2010 release of the IHSDM included implementation of HSM predictive methods.

The Idaho Transportation Department (ITD) used IHSDM as part of a comprehensive review of Idaho State Highway 8 corridor conditions. IHSDM was used to evaluate existing traffic, roadway geometric deficiencies, and potential safety issues, and to predict crashes using these data and the corridor's recent crash history. ITD found that more than half of the 18-km (11-mi) corridor studied exhibited a calculated crash rate higher than the statewide average. This information was used to help identify potential improvement locations.

Also supporting implementation of the HSM is the Crash Modification Factors Clearinghouse, which was created in fiscal year (FY) 2010. A Crash Modification Factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. Available online at www.cmfclearinghouse.org/index.cfm, the Clearinghouse consists of a database of CMFs, along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs.

States such as Illinois, Iowa, North Carolina, Virginia, and Washington are using the Clearinghouse to develop lists of CMFs that they can use

when performing benefit-cost analyses. The Washington State Department of Transportation, for example, is developing a tailored list of CMFs approved for use by the department. It will then distribute that list to potential applicants for local safety funding. The Iowa Department of Transportation also uses the Clearinghouse as a resource for local governments that are applying for site-specific safety funding through the State's Traffic Safety Improvement Program. Local governments can use the Clearinghouse's CMFs to perform benefit-cost analyses for each potential traffic safety improvement.

Improving Infrastructure Integrity

FHWA's comprehensive infrastructure research is resulting in new technologies that are reinventing the country's roads and bridges and producing a safer and smoother driving experience, while saving money and reducing congestion.

Mitigating Disaster Risks

According to the National Science and Technology Council's Subcommittee on Disaster Reduction, natural and human-caused hazards in the United States cost an estimated $52 billion per year in lives lost and economic damages. The FHWA Hazards Mitigation R&T program is helping to reduce hazard risks to highways and bridges, and ensure that highway infrastructure remains operational during and after a hazard event. Past research has included studies conducted at FHWA's Turner-Fairbank Highway Research Center (TFHRC) Hydraulics Research Laboratory to advance the understanding of the effects of flooding, scour, and coastal inundation on bridges. Researchers in TFHRC's Aerodynamics Laboratory, meanwhile, have developed measures to control bridge vibrations caused by wind.

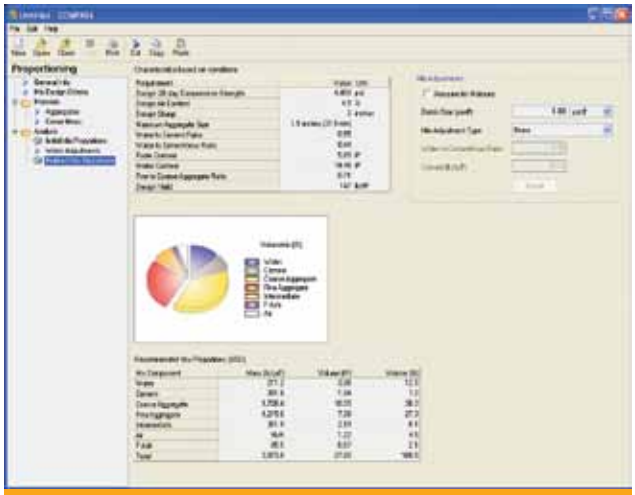
Research is now underway to develop technologies and methodologies for a number of major hazards, including flooding and scour, coastal inundation, wind and hurricanes, earthquakes, and technological hazards, including terrorism. Both advanced and applied research will continue in 2011 to improve prediction models and develop better design guidance and countermeasures for both new and existing structures. Some of the key FY 2011 initiatives include research on stream stability problems and the development of resulting design standards for bridges, as well as ongoing studies to improve the seismic resilience of bridges.

Two Decades of Advancements in Pavement Design and Management

More than 20 years after data collection began for the Long-Term Pavement Performance (LTPP) program, the benefits and products generated by the program continue to change pavement design and management worldwide. The LTPP database has played a critical role in the development and evaluation of every major pavement design methodology developed over the past 20 years. This includes the 1993 and 1998 AASHTO design procedures, the Superpave® mix design system, and the DARWin-ME™ pavement design software. This software gives engineers improved tools for specifying the optimum mix, layer configuration, and thickness for new and rehabilitated pavements. DARWin-ME would not have been possible without LTPP data for many inputs. Calibrated nationally with LTPP test sections, DARWin-ME has shown significant reductions in the initial cost for heavily trafficked pavement designs, and its use is expected to generate annual savings of $1 billion. Beyond overall design procedures, the LTPP data have supported and will continue to support model development and validation for a wide array of pavement performance predictors and indicators.

The program has monitored the performance of nearly 2,500 in-service pavement test sections throughout the United States and Canada, including 758 test sections that are still being monitored today. These test sections represent a range of climatic and soil conditions. The data collected now form the largest and most comprehensive pavement database in the world. LTPP data have been translated into an array of products and tools for pavement engineers, including data collection procedures, a new falling weight deflectometer (FWD) calibration system, an updated FWD calibration protocol, and equipment protocols for traffic data collection. The FWD calibration system provides a method to assure that data collected to assess the structural condition of pavements will be accurate and consistent. A nondestructive testing device, the FWD imparts a dynamic load to the pavement surface that is similar to that of a single heavy moving wheel load. The resulting pavement deflection can then be measured. This deflection data combined with the pavement layer thickness can be used to help analyze the remaining ser-

A falling weight deflectometer (FWD) is calibrated. Products and tools resulting from the Long-Term Pavement Performance program include a new FWD calibration system and an updated FWD calibration protocol.



FHWA's COMPASS software can be used to optimize the performance of a concrete mixture in a particular environment.

vice life of a pavement. These and other advancements resulting from LTPP research are detailed in a new report, *Long-Term Pavement Performance Program: Accomplishments and Benefits 1989–2009* (Pub. No. FHWA-HRT-10-071).

The LTPP program's LTPP Computed Parameter: Dynamic Modulus study developed estimates of the dynamic modulus of hot-mix asphalt (HMA) layers on LTPP test sections following the models used in the *Mechanistic-Empirical Pavement Design Guide*. Adopted by AASHTO in 2008, the new guide enables transportation agencies to better predict pavement performance over time and make more informed decisions when designing pavements. Additionally, LTPP*, a user-friendly software, was developed to facilitate dynamic modulus computations. This will allow transportation agencies to more accurately characterize the strength and load resistance of their asphalt mixes, resulting in better and longer lasting pavements. Nearly 400 copies of the software have been distributed to State agencies and others. More information on the software and study findings can be found in the new TechBrief, *LTPP Computed Parameter: Dynamic Modulus* (Pub. No. FHWA-HRT-11-018).

LTPP advancements will also benefit future pavement professionals. Several universities have introduced curricula that include LTPP data, for example. To encourage use of the data, FHWA and the American Society of Civil Engineers (ASCE) sponsored an International Contest on LTPP Data Analysis in 2010. The contest included categories for both undergraduate and graduate students, partnerships, and curriculum. Looking to the future, additional products and tools could result from efforts to optimize pavement treatment selection, assess the impact of the environment on pavement performance, and compare the performance of new materials to conventional materials.

Optimizing Concrete Pavements with COMPASS

Many factors, including project time constraints, demand for longer pavement design lives, and environmental, social, and economic considerations, are leading the concrete paving industry to come up with new ways to proportion and optimize concrete mixtures. Additionally, many concrete material choices are available today that add complexity to the mixture proportioning process. With all of these changes, the industry needed a tool for concrete mixture optimization that could isolate properties of interest and simplify the approach to the mixture proportioning process based on site-specific conditions. In response to this need, FHWA developed the Concrete Mixture Performance Analysis System (COMPASS). With this Windows®-based application system, a user can optimize the performance of a concrete mixture in a particular environment by properly selecting material constituents, such as types of aggregates, cementitious materials, and admixtures, that will benefit properties identified as important to a particular environment or project type. The user can also determine the appropriate gradation and material constituent proportions that will enhance the performance of a mixture. These benefits will result in longer-life pavements.

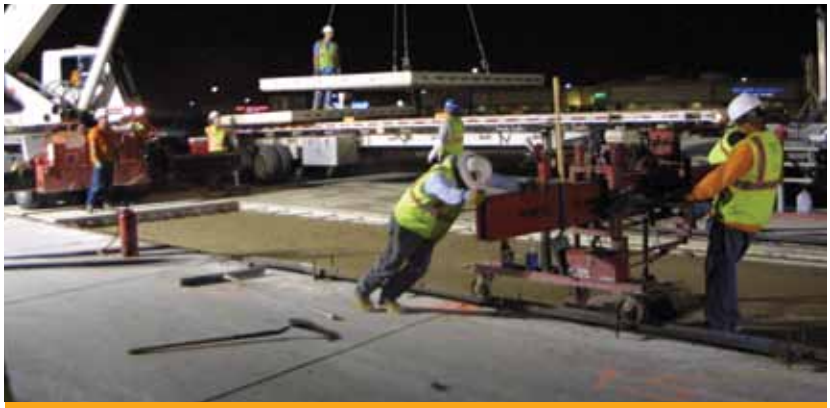
CA4PRS: Get In, Get Out, Stay Out

As transportation agencies balance the need to rehabilitate and reconstruct existing highways with the goals of reducing congestion and improving safety, accelerated construction is more important than ever. A new software tool, Construction Analysis for Pavement Rehabilitation Strategies (CA4PRS), assists agencies in making accelerated construction a reality. The software was developed under an FHWA pooled fund study by the Institute of Transportation Studies at the University of California at Berkeley. California, Minnesota, Texas, and Washington participated in the study. All States can now obtain the software and training at no charge.

CA4PRS can be used to identify optimal highway rehabilitation strategies that balance the construction schedule with inconvenience to drivers and transportation agency costs. The program's scheduling module estimates project duration, while its traffic module quantifies the impact of work zone lane closures on the traveling public. The cost module estimates total project cost (including construction, traffic handling, and supporting costs). A growing number of States are using CA4PRS, including California, Utah, and Washington. Approximately 20 States have obtained the software. The California Department of Transportation (Caltrans), for example, used it in the design stage of a recently completed project on I-15 in Ontario to select the most efficient rehabilitation strategy for the roadway. Caltrans' use of the software on a previous project on I-15 in Devore cut construction and traffic control costs by 25 percent, saving $6 million, and an additional $2 million in road user costs. "A key benefit of using CA4PRS is that it allows us to get in and get out faster, reducing both the length of construction projects and traffic congestion," said Michael Samadian of Caltrans.

Enhanced Bridge Inspections Through Nondestructive Evaluation

Following the collapse of the I-35W bridge in Minneapolis, Minnesota, in 2007, FHWA developed a Bridge Inspection Nondestructive Evaluation Showcase to give bridge owners, managers, and inspectors training in the latest nondestructive evaluation (NDE) tools and systems. NDE methods can be used to assess existing conditions in highway bridges during routine inspections, supplementing visual inspections and improving the overall reliability of bridge evaluations. The showcase is now offered through NHI (Course No. FHWA-NHI-130099). FHWA is also conducting numerous other studies intended to advance NDE practice and help develop and deploy new tools and technologies that aid in assessing the condition of the Nation's physical infrastructure. Work underway includes researching NDE methods as well as developing resources for bridge owners and inspectors. A current research project is focusing on developing an advanced method of measuring corrosion and section loss in gusset plates, with an emphasis on multiple plates and areas that are not visible for inspection. An ongoing project is investigating using response-based analysis of in-service bridges to increase the accuracy of load ratings. One benefit of this increased accuracy is to minimize load restrictions for bridges. These research projects and other NDE



The CA4PRS software identifies optimal highway rehabilitation strategies that balance the construction schedule with inconvenience to drivers and transportation agency costs.

Nondestructive evaluation tools and systems for bridges highlighted in FHWA's Bridge Inspection Nondestructive Evaluation Showcase include the Ultrasonic system (left) and the Eddy Current system (right).

methods that range from simple to highly advanced will be documented in FHWA's forthcoming *NDE Web Manual*. The manual, which will be hosted on the FHWA Web site, will feature information on NDE methods and link the methods with the inspection situations where they should be used.

RealCost Produces Real Savings

FHWA's RealCost software is a tool for performing life cycle cost analysis (LCCA) for pavement selection. The software can also be used for bridges and structures. LCCA provides a cost comparison between two or more competing design alternatives that produce equivalent benefits for the project being analyzed, evaluating agency and user costs over the life of the various alternatives. Because LCCA focuses on costs required over the life of an asset to maintain it above some minimum performance level, the lowest cost alternative is not necessarily the one with the lowest cost of initial construction. Using RealCost, agencies can analyze up to six design alternatives simultaneously. Up to four different traffic distributions, such as for a weekday or weekend, can also be defined and selected. Currently available in Version 2.5, which was released in 2010, the software calculates life cycle values for both agency and user costs associated with construction and rehabilitation. Numerous States have adopted RealCost for pavement LCCA and several, including California, Colorado, Florida, and Washington, have formally incorporated it into their pavement type selection policy or process. FHWA continues to enhance the RealCost software, incorporating user feedback and research findings. A new version of the software is expected to be released in 2012.

Pavement Materials Laboratories

Work at TFHRC's Pavement Materials Laboratories includes conducting forensic analyses of paving materials for State DOTs. Staff at the laboratories have collaborated with the Georgia, Maine, New Hampshire, New York, and Virginia DOTs and FHWA's Office of Federal Lands Highway on several projects. Researchers have also worked with States and asphalt and asphalt additive producers to evaluate the durability of bituminous and aggregate components.

The laboratories independently verify contract research results, provide unbiased support to State agencies and industry, and assist State and Federal agencies and industry with forensic analyses. The laboratories also conduct fundamental studies of highway materials. These studies advance understanding of pavement failure mechanisms and superior performance, assist in the development of state-of-the-art characterization tools and tests, and foster the development of new materials and mix designs. Through these efforts, numerous forensic tools have been developed, including test methods to determine the presence of additives such as lime and polyphosphoric acid. The tools aid in assessing the causes of premature pavement failures. Ultimately this can help identify more durable pavement materials, identify less expensive materials with equal or improved performance characteristics, and assist in advancing pavement sustainability efforts.

Full-scale pavement tests have been completed at TFHRC's Accelerated Loading Facility (ALF) to evaluate the fatigue and rutting resistance of both polymer modified and unmodified binder, crumb rubber, and fibers. Currently, fine-graded thin asphalt overlays with updated specifications for Superpave 4.75 mm (0.18 in) nominal maximum aggregate size mixes are being investigated. The ability to defer cracking, reduce long-term aging, and increase net pavement life is being quantified through this research.

A final ALF report on *Full-Scale Accelerated Performance Testing for Superpave and Structural Validation* will be available this year. The research identified two candidate purchase specification tests for asphalt binder that better classify the fatigue cracking and rutting performance than the current Superpave tests. This will enable State agencies to specify and select more durable asphalt binders.

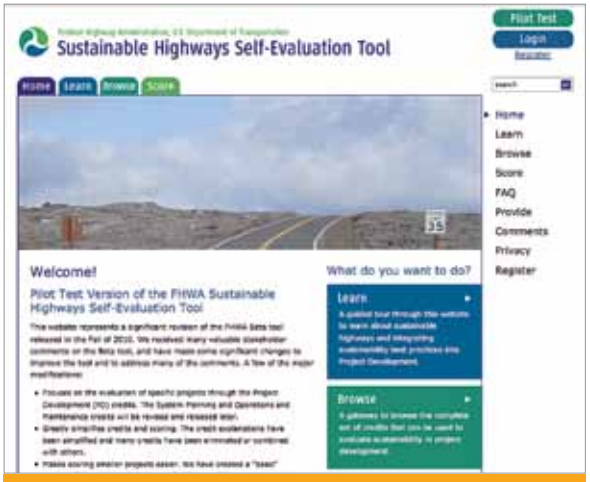
Strengthening Transportation Planning and Environmental Linkages

FHWA researchers are not only working to build safer and more durable roads and bridges but to build them more sustainably, reducing the impact of highway infrastructure on the environment. This includes efforts to accelerate construction and reduce congestion and related emissions, reduce the runoff from highways, increase the reuse and recycling of roadway materials, and reduce the energy required for highway construction.

Making Highway Projects More Sustainable

As transportation agencies seek to build sustainable highways that meet development and economic growth needs, while reducing impacts on the environment and consumption of natural resources, tools are needed to help agencies quantify sustainability and support their decisions. Released in 2010, FHWA's Sustainable Highways Self-Evaluation Tool will provide valuable assistance to State DOTs and Metropolitan Planning Organizations (MPOs) as they work to make their highway projects more sustainable. With support from FHWA's flexible, cross-functional research funding, the tool was developed in cooperation with State and local transportation agencies and organizations such as AASHTO and ASCE. States and MPOs can use it to evaluate their projects and practices and rate them using a consistent set of evaluation criteria and scores.

This unique tool addresses the full life cycle of a highway project, from planning through construction to operations and maintenance. Sustainability is measured through goals and credits for sustainable highway practices, projects, and programs. Each credit describes a particular practice, provides methods for implementing it, and includes examples where it has been successfully applied. The self-evaluation tool includes 68 credits, organized into system planning, project development, and operations and maintenance. Some agencies may use the sustainability tool to learn about how others are addressing sustainability or to find out more about certain sustainability practices that can be applied to a project, while other agencies may use it to track the performance of projects over time. Available in a beta version online at www.sustainablehighways.org, the tool offers users maximum, hands-on flexibility. Through a pilot testing initiative, FHWA will continue to refine and improve it.



Available online at www.sustainablehighways.org, FHWA's Sustainable Highways Self-Evaluation Tool provides a boost to State transportation departments and Metropolitan Planning Organizations as they seek to evaluate projects and quantify sustainability.

Recycling Solutions

Recycling asphalt pavement creates a cycle of reusing materials that optimizes the use of natural resources. Reclaimed asphalt pavement (RAP) reduces the need to use virgin aggregate, which is a scarce commodity in some areas of the United States, and cuts the energy and transportation costs needed to obtain the aggregate. It also reduces the amount of costly new asphalt binder required in the production of asphalt paving mixtures. The state of the practice for RAP use in the United States, as well as best practices for increasing the use of RAP in asphalt pavement mixtures while maintaining high-quality pavement infrastructure, is detailed in a new FHWA report, *Reclaimed Asphalt Pavement in Asphalt Mixtures: State of the Practice* (Pub. No. FHWA-HRT-11-021). The report provides useful information on RAP percentages and asphalt binder grade selection, mix design considerations, and performance of RAP asphalt mixtures.

From 2007 to 2009, about half of States reported increased use of RAP, with the average percentage of RAP used in HMA around 15 percent. Analyses by FHWA have shown that the performance and life of pavements containing up to 30 percent RAP is similar to virgin pavements containing no RAP. The ability to use 30 percent RAP in asphalt mixtures, compared to no RAP, can result in cost savings of more than $5 per ton of asphalt. Research led by FHWA has also shown that up to 20 percent RAP can be used in an HMA mixture without having to make changes to the asphalt binder. Using 20 percent RAP compared to 15 percent RAP results in cost savings of at least $1.25 per ton of asphalt. Based on the amount of HMA and warm mix asphalt (WMA) produced in 2010 and the amount of RAP used in HMA and WMA, this could result in savings of $125 million annually.

Reducing Congestion, Improving Highway Operations, and Enhancing Freight Productivity

According to the Texas Transportation Institute, congestion cost Americans more than $100 billion in time and fuel in 2009, draining money and productivity and hampering freight operations. Research into congestion solutions has never been more crucial.

A Foundation for Future Mobility

TFHRC's new multimodal Transportation Operations Laboratory contains test beds for developing data resources, transportation concepts and analysis, and cooperative vehicle-highway interfaces. Offering a foundation for the future, the lab's research will explore how innovative technologies can dramatically change and improve the performance of the Nation's transportation system. The lab's concepts and analysis test bed, for example, will be used to conduct "what-if" simulations to assess the impact of different technologies and policies. Research into vehicle-highway interfaces, meanwhile, will explore how traffic signals can "talk" to cars and mobile devices and cars can then "talk" to other cars and traffic signals about where they are and how fast they are going. This research could lead to significant decreases in delays and a reduction in the number of crashes that occur during stop-and-go traffic.

Targeted Safety Messages Talk to Your Vehicle

Operations research that will use the Cooperative Vehicle-Highway Testbed (CVHT) in FHWA's new Transportation Operations Laboratory includes the Signal Phase and Timing (SPaT) Interface Definition and Prototype, which will define a common two-way interface between vehicle systems, mobile devices, and traffic signal controllers. This would enable applications such as warning drivers they are about to violate a red light and optimizing traffic flows through intersections, which can reduce emissions and fuel usage. The first two prototype controllers to use this new interface will be tested in the CVHT in late 2011 and early 2012.

FHWA is also supporting the procurement of roadside equipment that will enable wireless communications between vehicles and infrastructure for the Connected Vehicle Safety Pilot, which is being led by the Intelligent Transportation Systems (ITS) Joint Program Office of the U.S. Department of Transportation's (U.S. DOT) Research and Innovative Technology Administration. Beginning in 2011 and running through the first half of 2013, this major research initiative will test how drivers in real-world conditions will respond to wireless safety messages targeted to them based on their specific position, situation, or vehicle type. These messages could include warnings such as "Use Caution, Icy Roads Ahead" or "Stop! Red Light Ahead" and address crashes associated with driving too fast for the conditions or driver distraction.

Among the concepts being developed at FHWA's Transportation Operations Laboratory is connected vehicle technology, which can reduce delays and the number of crashes that occur during stop-and-go traffic.

Traffic Signal Triggers

FHWA researchers are using step-frequency ground-penetrating radar (SF-GPR) to develop a nondestructive method for detecting and assessing inductive loop sensors that are embedded in roadway surfaces. The SF-GPR technology offers advanced subsurface three-dimensional imaging capabilities. The sensors being assessed indicate the presence or movement of vehicles and provide information that supports such traffic management applications as signal control and freeway mainline roadway and ramp control. Malfunctioning sensors can prevent traffic signals from sensing the presence of vehicles, which can be both frustrating for drivers and delay or prevent the display of green signal indicators to motorcyclists and bicyclists. Since research began in 2006 under a Small Business Innovation Research project, FHWA has improved the GPR detection and resolution capability

FHWA researchers are using step-frequency ground-penetrating radar to develop a non-destructive evaluation method for detecting and assessing inductive loop sensors imbedded in roadway surfaces. Malfunctioning sensors can prevent traffic signals from sensing the presence of vehicles.

and made significant steps in advancing the technology to the point where it can be commercialized.

Assessing Policy and System Financing Alternatives

In difficult economic times and an era of reduced budgets, transportation agencies face the challenge of doing more with less. R&T initiatives not only build better infrastructure but explore how agencies can assess policy and system financing alternatives.

Passenger Travel Analysis Framework: An Efficient Decisionmaking Tool

FHWA and its State and local partners have historically relied upon modeling tools to support their planning, analyses, and decisionmaking processes. Modeling tools demonstrate the relationships among congestion reduction, greenhouse gases, emissions, fuel use, fuel prices, and other relevant factors. Using flexible, cross-functional research funds, this project developed mathematical functions and models that link population, licensed drivers, number of available vehicles, freight demand, driver behavior, energy/fuel price and availability, environmental issues and concerns, and vehicle miles traveled (VMT). These models are used by U.S. DOT and FHWA to forecast VMT, analyze various scenarios, and as an aid in planning and decisionmaking. The models also provide technical approaches to States, local agencies, and private businesses in developing local models.

A model for national VMT for 2040 has also been developed and used by U.S. DOT and FHWA for safety and other benchmarking analyses and additional analysis, including energy consumption and greenhouse gas emissions. This project has provided, for the first time, a comprehensive forecasting of VMT by vehicle type, area type, energy consumption, emissions, and potential gas tax revenue through 2040. A State VMT model for 2040 is also available, with regional models and a motorcycle VMT component in the development stage.

The goal of the Passenger Travel Analysis Framework, which encompasses the work of several interconnected FHWA programs, is to enable a better understanding of national travel demand and provide States with resources for better analyzing and meeting travel need challenges.

Exploring Next Generation Solutions

FHWA highway research is creating a better, safer driving experience for today, but it is also looking at the infrastructure that will define tomorrow. From cutting-edge technologies inconceivable a generation ago to "smart" pavements and bridges that are just around the corner, the next generation of transportation has already begun.

Developing the Next Generation of Bridges and Asset Management Tools

The Long-Term Bridge Performance (LTBP) program is leading the way toward a better future for bridge performance. The program will collect, maintain, and study high-quality, quantitative performance data for a representative sample of bridges nationwide. These bridges will feature many structural types and materials, as well as variations in geometry, age, traffic volume, truck loads, and climatic conditions. Data collected by the program will support a better understanding of how and why bridges deteriorate, how to best prevent or mitigate deterioration, and how to most effectively focus the development of the next generation of bridge management tools. Pilot studies to

Among the structures being studied as part of the Long-Term Bridge Performance program is this bridge on Westbound State Road 430 over the Halifax River in Daytona, Florida.

Pilot bridges for the Long-Term Bridge Performance program include this bridge in Sandstone, Minnesota, which carries State Road 123 over the Kettle River.

The Long-Term Bridge Performance program is collecting data for this bridge on Eastbound Interstate 95 over Sharon Station Road near Allentown, New Jersey.

assess program protocols and data management systems are now being conducted at seven bridges across the country. Located in California, Florida, Minnesota, New Jersey, New York, Utah, and Virginia, the pilot bridges represent both a broad geographic distribution and a cross section of the bridges on which the LTBP program will focus. The program will concentrate on the types of bridges heavily represented in the U.S. bridge population, including highway and interchange overpasses and bridges over minor waterways. The pilot phase is currently underway and will be completed in 2011, with the longer-term data collection phase to follow. While the data collection will occur over an extended period of time, an immediate payoff from the program will be the ability to integrate data from nondestructive testing and monitor bridge deterioration.

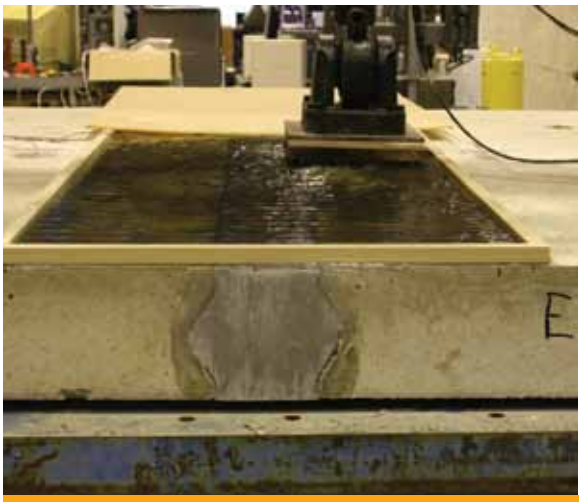
A New World of Ultra-High Performance Concrete

As the Nation looks to build longer lasting bridges and more rapidly renew its highway infrastructure, the use of high-strength and high-performing materials is more important than ever. For more than 10

years, FHWA's structural concrete R&D program has worked to take concrete to new levels with the implementation of ultra-high performance concrete (UHPC). Exhibiting superior properties such as exceptional durability, high compressive strength, and long-term stability, UHPC components can facilitate accelerated construction and allow for the use of longer spans. States such as Iowa, New York, and Virginia are now beginning to use the new technology. In Buchanan County, Iowa, for example, the construction of the Jakway Park Bridge received a boost with the successful use of a new type of UHPC bridge girder developed through the FHWA R&T program. This was the first bridge in the country to be built using the UHPC technology, demonstrating the viability of the concept from design, through construction, and into everyday use.

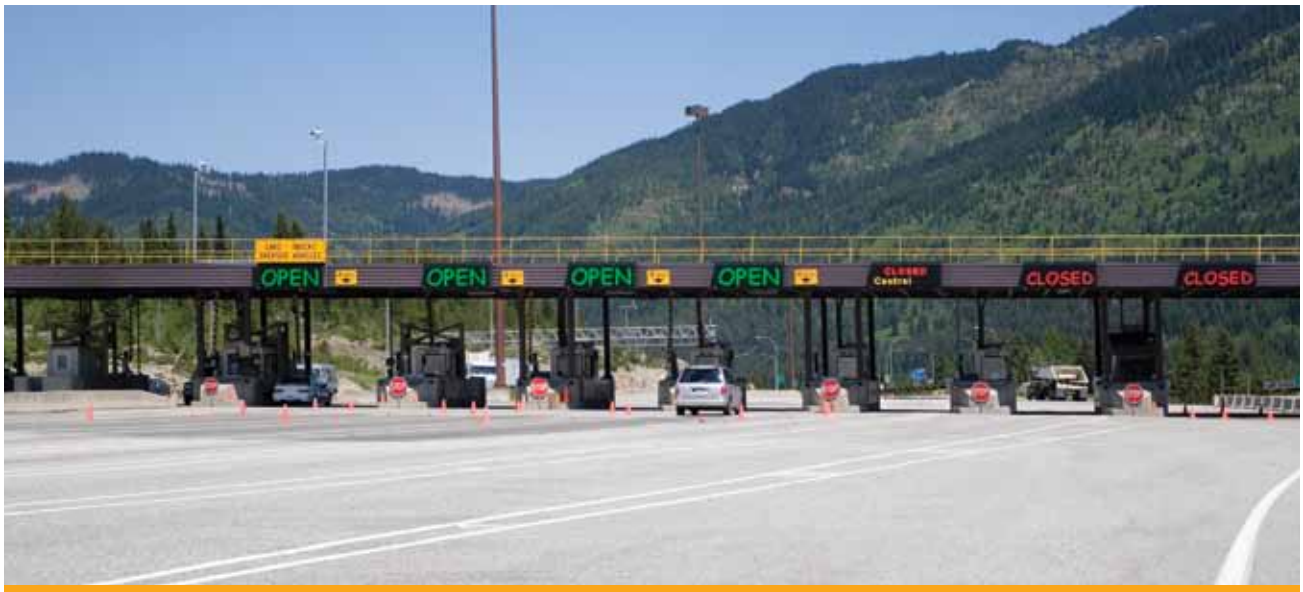
UHPC research focal areas are advancing, including through a Transportation Pooled Fund project being conducted in partnership with the New York State Department of Transportation (NYSDOT) and the Iowa Department of Transportation. The project is evaluating the performance of novel field-cast UHPC connections linking prefabricated bridge girders to precast concrete bridge decks. While the use of modular bridge deck components can produce higher quality, more durable bridge decks, the required connections have often been lacking, diminishing the overall system performance. The new UHPC connection eliminates the conflict points between the deck reinforcing bars and the girder shear connectors, allowing for easy field assembly. NYSDOT hopes to use the concept in a highway interchange reconstruction project in 2011.

The story of UHPC and the unique solutions it offers is told in a new FHWA TechNote, *Ultra-High Performance Concrete* (Pub. No. FHWA-HRT-11-038).



Ultra-high performance concrete connections are tested at FHWA's Turner-Fairbank Highway Research Center. These connections can link prefabricated bridge girders to precast concrete bridge decks.

Ultra-high performance concrete pi-girders were used in the construction of the Jakway Park Bridge in Buchanan County, Iowa.



Exploratory Advanced Research program projects include one designed to develop best practices for highway revenue collection.

Exploratory Advanced Research

FHWA's Exploratory Advanced Research (EAR) program focuses on long-term, high-risk research with a high payoff potential. The program addresses underlying gaps faced by applied highway research programs, anticipates emerging issues with national implications, and reflects broad transportation industry goals and objectives.

The EAR program has conducted initial investigations in over 100 topics—through reference searches, scanning trips, and convening workshops—to assure leverage of the most recent, relevant, and advanced research from all fields. From the initial topics, the EAR program invested funding in 44 projects from 2007 through 2010, representing 32 topics that could bring together scientific and engineering advances and attract multidisciplinary research teams to solve critical highway research issues.

One promising project, "Development and Evaluation of Selected Mobility Applications for VII," conducted by the California Partners for Advanced Transportation Technology Program in cooperation with Caltrans, is advancing the capabilities of intelligent vehicles to reduce congestion and effectively increase highway capacity.

Another EAR program-sponsored project, "Behavioral Sciences Approach to Testing, Validating, and Establishing Best Practices for Alternative Highway Revenue Collection," led by the University of Central Florida, is applying novel experimental approaches for measuring fundamental behavioral characteristics in order to properly understand traffic behavior, and to design best practices for highway revenue collection.

Also underway is "Nanoscale Sensors for Structural Health." Conducted by the Georgia Institute of Technology, this project is investigating self-powered, very-large-area wireless sensors for the real-time monitoring of potentially dangerous cracks in steel bridges. The sensors are made by the inkjet printing of nanoparticles onto thin, flexible circuit boards.

Moving Innovation

New FHWA initiatives are accelerating the deployment of innovation, putting new products and technologies in the hands of the State and local agencies that need them today.

Every Day Counts

Rapid deployment of proven technology and solutions to speed up project delivery are at the heart of FHWA's new Every Day Counts (EDC) initiative. The EDC initiative is designed to identify and deploy proven, ready-to-go innovation aimed at shortening project delivery, enhancing roadway safety, and protecting the environment. Teams from FHWA are working with State, local, and industry partners to implement the EDC technologies and to achieve better, faster, and smarter ways of doing business. Priority technologies include many developed or advanced through FHWA research, such as warm mix asphalt (WMA), prefabricated bridge elements and systems (PBES), Adaptive Signal Control Technology (ASCT), and the Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS).

ASCT adjusts signal timing to account for the variability in traffic demand that conventional traffic signals cannot accommodate, thereby improving traffic congestion and safety. Locations that have used this technology include Anne Arundel County, Maryland; San Ramon, California; San Marcos, California; Los Angeles, California; Bellevue, Washington; and Ann Arbor, Michigan.

The Bowman Road Bridge in Defiance County, Ohio, was the first bridge in the world to use the Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS).

The Safety Edge℠ technology provides a simple but effective solution to reduce pavement edge-related crashes and help save lives. By shaping the edge of a pavement to 30 degrees, the Safety Edge helps mitigate the problem of vertical drop-off, enabling vehicles to return to the paved road smoothly and easily.

WMA encompasses a variety of technologies that allow asphalt to be produced and then placed on the road at lower temperatures than the conventional HMA method. The lower temperatures may result in cost savings and reduced greenhouse gas emissions because less fuel is required. WMA is a proven technology that improves compaction, which then improves pavement performance, reduces fuel and energy usage, and increases worker comfort by reducing exposure to high temperatures and odors. WMA also has the potential to extend the construction season, allowing projects to be delivered in a timelier manner. TFHRC staff conducted early experiments when WMA technologies emerged and have been active participants in subsequent research and the deployment of WMA across the Nation.

FHWA has also supported research on PBES, as well as deployment of the new technology. The prefabricated systems can be manufactured offsite at a prefabrication plant or adjacent to the project site by the contractor, under controlled conditions, and brought to the bridge location ready to install. The use of PBES, ranging from superstructures or substructures to totally prefabricated bridges, offers both faster and safer bridge construction and better quality. PBES can also reduce costs and the environmental impact of projects. FHWA's *Connection Details for Prefabricated Bridge Elements and Systems* manual (Pub. No. FHWA-IF-09-010) provides

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Utah is among the States now using prefabricated bridge elements and systems. Here, the prefabricated superstructure of the 4500 South bridge in Salt Lake City is installed.

By consolidating the edge of a pavement to 30 degrees, the Safety Edge℠ helps mitigate the problem of vertical edge drop-off.

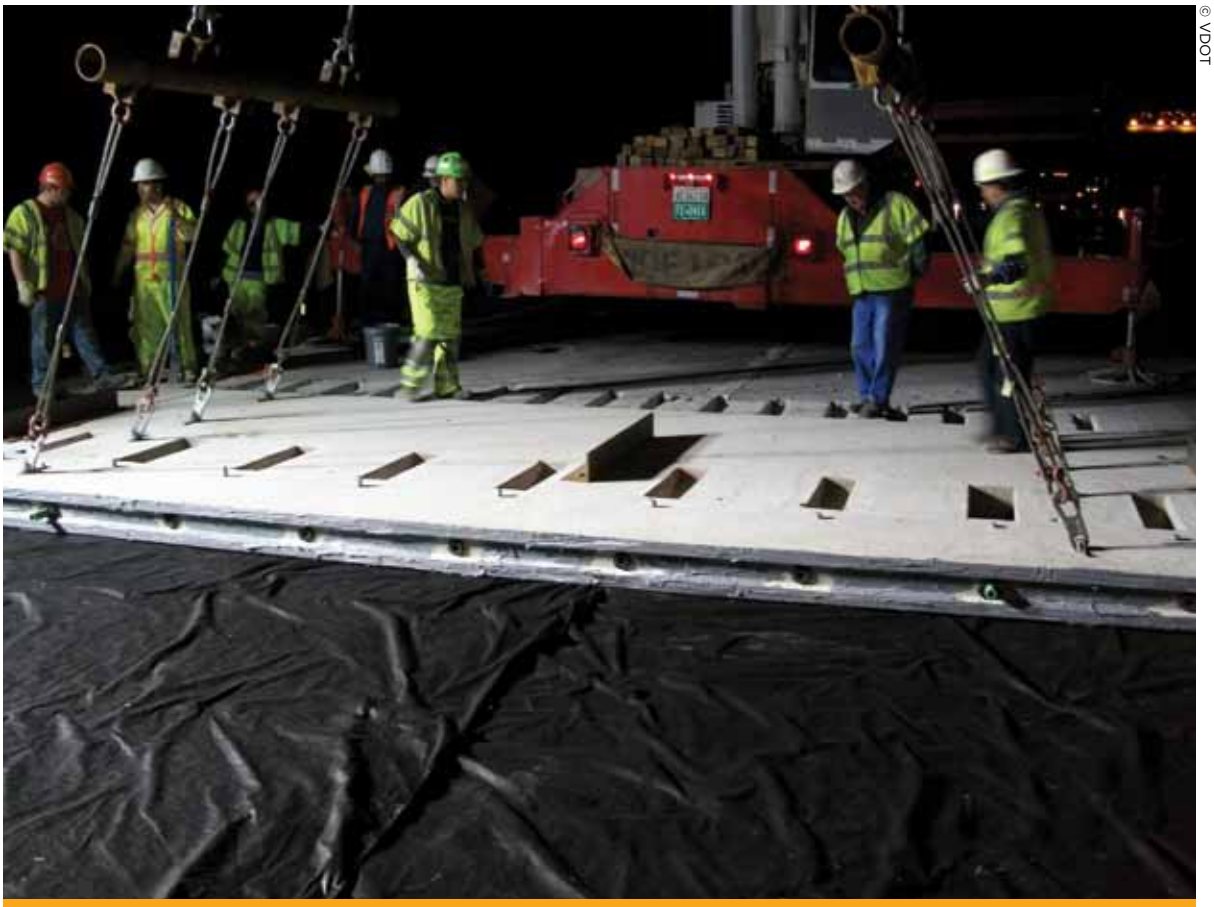
transportation agencies, contractors, and consultants with information on the state of the practice for accelerated bridge construction across the country.

In States such as Ohio and New York, GRS-IBS technology is revolutionizing bridge building by alternating layers of compacted local soil and sheets of geotextile fabric reinforcement to build abutments and provide support for the structure. Researchers at the U.S. Forest Service and the Colorado Department of Transportation (CDOT) pioneered the early development of the GRS technology. FHWA then worked with CDOT to further refine it. Today, FHWA is continuing to refine and broaden the applicability of the technology. The result is bridges that are both extremely durable and cost effective, with costs potentially reduced by 25 to 60 percent. The GRS-IBS method also blends the roadway into the superstructure to create a jointless interface between the bridge and the approach roadways, alleviating the common "bump" caused by differential settlement between bridge abutments and approach roadways. GRS-IBS can be built with readily available materials, using common construction equipment, and without the need for highly skilled labor.

New FHWA publications continue to advance the deployment of the GRS-IBS technology, including the *Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide* (Pub. No. FHWA-HRT-11-026) and the *Geosynthetic Reinforced Soil Integrated Bridge System Synthesis Report* (Pub. No. FHWA-HRT-11-027). The guide takes engineers through the site selection, design, and construction process for GRS-IBS, while the companion report substantiates the design method and presents case histories for GRS-IBS bridges built to date.

Highways for LIFE

Launched in 2005, the Highways for LIFE (HfL) program focuses on achieving the Long-lasting, Innovative, and Fast construction of Efficient and safe highway infrastructure, thereby improving highway safety and quality while reducing the time needed to complete projects and the congestion caused by construction. HfL aims to raise awareness in the highway community so that new technologies can be moved from the state-of-the-art to the state-of-the-practice much more quickly. The program provides funding for innovative projects, training for highway professionals, partnering with private sector innovators, and publicity to raise awareness among both the highway community and the driving public. Technologies supported by HfL grants to States and promoted through workshops, videos, publications, and other resources include PBES, road safety audits, and tools for "Making Work Zones Work Better."



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Precast, prestressed concrete panels are installed on I-66 in Fairfax County, Virginia, as part of a project supported by Highways for LIFE funding.

In FY 2010, the New Hampshire Department of Transportation received funding to use innovative technologies such as precast panels and high-performance materials when it rehabilitates a bridge on U.S. 3/NH 11 Bypass in Gilford. In Missouri, HfL funding will support the use of hybrid composite beams for the construction of three bridges. The project is part of Missouri's Safe and Sound Bridge Improvement Program, which is replacing or reconstructing the State's lowest rated bridges by 2013. Use of the hybrid-composite beams, which are lighter than conventional concrete beams and require minimal maintenance, is expected to reduce project construction time by about 25 percent. The beams have a fiber-reinforced plastic shell that is expected to provide a service life beyond 100 years. And in Vermont, the Department of Transportation will use a HfL grant to incorporate trenchless technology as part of the rehabilitation of two culverts along Interstate 89 in South Burlington and Colchester. The technology involves installing linings in existing culverts, rather than excavating the roadway and replacing the culvert. This innovation will minimize traffic disruptions and increase worker safety, while cutting costs.

For FY 2011, more than $9.5 million in HfL grants were awarded to 15 projects in 14 States to help agencies build projects smarter, faster, cheaper, and with less impact on the traveling public. The funding supports the use of such innovations as precast concrete pavement slabs, PBES, WMA, road safety audits, and the Safety Edge paving technique.

HfL also collaborates with the highway construction industry through its Technology Partnerships Program to accelerate the adoption of promising innovations. In 2010, funding was awarded to promote the implementation of composite bridge decking for moveable bridges.

SHRP 2

Conducted from 1988 to 1993, the first Strategic Highway Research Program (SHRP) had a significant and lasting impact on the country's roadways. Its focused, results-oriented research led to such breakthrough advances as the Superpave asphalt pavement design system, as well as implementation of high-performance concrete pavements and bridges, new winter maintenance techniques, and pavement preservation strategies, among other innovations. Building on this success, a second program (SHRP 2) was authorized in 2005 under the SAFETEA-LU Act with the goal of developing recommended procedures, practices, and applications to advance the Nation's highway system. The program is managed by TRB, in close cooperation with FHWA and AASHTO. The key focus areas for the program are:

- *Safety*—Prevent or reduce the severity of highway crashes by understanding highway behavior.
- *Renewal*—Address aging infrastructure through rapid design and construction methods that cause minimal disruption and produce long-lived facilities.
- *Reliability*—Reduce congestion through incident reduction, management, response, and mitigation.
- *Capacity*—Integrate mobility, economic, environmental, and community needs in the planning and designing of new transportation capacity.

Over 80 SHRP 2 research projects are underway in the four focus areas, with a dozen completed to date, and most projects expected to conclude by 2013. With the extension of SAFETEA-LU, the SHRP 2 program has likewise been extended, allowing TRB extra time and budget resources to test and improve products developed during the original research phase of the program, fill gaps in the research, and plan for implementation. One completed high-value research project is Renewal Project R26: Preservation Approaches for High-Traffic-Volume Roadways. This initiative produced *Guidelines for the Preservation of High-Traffic-Volume Roadways,* which will help expand transportation agencies' ability to use varied treatments to best meet the preservation needs on higher-volume roadways. Utility issues are another high-priority research topic, as utilities are among the major causes of delay in highway projects. Among the resulting products are reports on *Encouraging Innovation in Locating and Characterizing Underground Utilities* and *Integrating the Priorities of Transportation Agencies and Utility Companies.*

In its 2009 report to Congress (Special Report 296), TRB recommended that FHWA serve as the principal implementation agent for SHRP 2. Toward that end, FHWA is in the process of assessing the alignment of emerging SHRP 2 products with the Agency's current program areas, and identifying potential priorities for deployment within those programs. With the December 2010 amendment of Section 510 of Title 23 of the U.S. Code, allowing the Secretary of Transportation to use SHRP 2 funds for implementation of SHRP 2 research products, FHWA is authorized to begin to engage in SHRP 2 development, demonstration, evaluation, and technology transfer activities.

As more research projects move toward completion, FHWA will be taking an increased leadership role in SHRP 2 implementation.

Partnerships

FHWA's R&T agenda is bolstered by the many national and international partnerships that support innovative, breakthrough highway research.

National Partnerships

Transportation Pooled Fund Program

The Transportation Pooled Fund Program provides Federal, State, and local transportation agencies; academic institutions; foundations; and private industry the opportunity to jointly fund transportation research. Pooled fund studies have led to significant advances in technology, including the SafetyAnalyst software, which was jointly sponsored by FHWA and 27 State highway agencies. An LTPP pooled fund study, Falling Weight Deflectometer Calibration Center and Operational Improvements, has produced an improved FWD calibration system and protocol, which provide for collecting high-quality pavement data and performing quality control and assurance. And the CA4PRS (Construction Analysis for Pavement Rehabilitation Strategies) software, also developed through a pooled fund study, is helping States identify optimal highway rehabilitation strategies and make accelerated construction a reality.

Cooperative Highway Research

Also leading the way on highway research is the TRB-administered and State-sponsored NCHRP. By pooling resources and concentrating on topics of significant interest to States, NCHRP studies are changing practices across the country, leading to advances nationwide in everything from safety and design, to highway planning and operations, to construction and context sensitive solutions (CSS).

The CA4PRS software, developed through an FHWA pooled fund study, helps States optimize highway rehabilitation strategies.

NCHRP research has helped transportation agencies choose the appropriate winter maintenance strategies for their roadways.

Quantifying the Benefits of Context Sensitive Solutions (NCHRP Report 642), for example, presents successful practices that transportation agencies have used to assess the value and benefits of integrating CSS principles in project development. These benefits include minimized overall impact to the human and natural environment, improved safety, and improved quality of life for communities. *Snow and Ice Control: Guidelines for Materials and Methods* (NCHRP Report 526), meanwhile, is helping agencies choose the appropriate winter maintenance strategies for their roadways.

State Research

State research is also producing big innovations. The State Planning and Research program provides Federal-aid funding to States to address their particular challenges. As AASHTO highlighted in its *Research Makes the Difference 2010* publication, despite the difficult economic times, States are committed to finding smarter transportation solutions. The Pennsylvania Department of Transportation, for example, is developing a guide on repairing damaged prestressed concrete bridge systems. The Alabama Department of Transportation (ALDOT) has developed a tool for better forecasting freight demand. And the North Carolina Department of Transportation has implemented an improved system of vehicle detectors and signal timing software to reduce the number of intersection collisions on high-speed roads. In every State, innovations such as these are the result of valuable highway research.

University Transportation Centers

The University Transportation Centers (UTC) program is a critical part of the U.S. DOT's efforts to use cutting-edge technologies and innovations to find solutions to the transportation challenges of the 21st century. Initiated in 1987, the program's 60 centers are integrated within institutions of higher learning throughout the country, serving as vital sources of transportation research and incubators of new ideas. The centers also help to develop the next generation of transportation professionals. The UTC program is administered by U.S.

Through the State Planning and Research program, ALDOT has developed a tool for better forecasting freight demand.

DOT's Research and Innovative Technology Administration. Each UTC focuses its research on a specific transportation theme. Recent themes have included developing tools to support greenhouse gas emission reductions, improving highway safety by identifying high-risk rural road segments and safety countermeasures, and conducting nondestructive evaluations of roadways.

Solving Transport Challenges Globally

Collaboration with international partners on transportation research and the exchange of specialized knowledge and experience will allow for more breakthrough advances and lay the groundwork for the next generation of global researchers. FHWA's international cooperation on research and technology deployment is focused on both exploring foreign technology innovations for possible adaptation and use in the United States and facilitating the use of tested U.S. technologies in other countries, including developing countries. This international collaboration includes facilitating the transfer of research-based knowledge and best practices through the establishment of Technology Transfer Centers in the Caribbean, Latin America, Sub-Saharan Africa, and parts of Eastern Europe and Russia. In an era where economic productivity is tightly linked to transportation efficiency, advancing a more efficient global transportation system enables economic growth and development around the world.

Through a variety of partnerships and interactions, FHWA's international activities address the U.S. transportation community's demand for access to information on state-of-the-art technology and practices used worldwide. These relationships involve technical workshops and exchanges, partnerships between State DOTs and international counterparts, participation in international organizations, and other information and technology sharing activities. The international programs can also provide support for U.S. foreign policy goals and may also lead to opportunities for the U.S. private sector. Among these programs is the International Technology Scanning Program sponsored by FHWA, in cooperation with AASHTO and NCHRP. This program identifies best practices and emerging technologies for implementation in the United States.

Learning about the use of prefabricated bridge elements and systems in Europe and Japan, for example, accelerated the implementation of the technology in the United States. After observing the use of self-propelled modular transporters (SPMTs) to rapidly transport and install prefabricated bridges in Europe, adopting the use of SPMTs was the top implementation recommendation. SPMTs are multi-axle, computer-controlled platform vehicles that can move in any horizontal direction and also have vertical lift. States such as Florida, Rhode Island, and Utah were among the first to employ SPMTs to accelerate bridge projects in the United States. Florida, for example, used prefabricated bridge elements and SPMTs to cut 4 months off the project schedule for construction of the new Graves Avenue Bridge in Volusia County. The accelerated construction resulted in $3 million in user cost savings.

A recently released report on *Advancing Bridge Safety and Serviceability* presents information on

safety and serviceability practices related to the design, construction, maintenance, and management of bridges. Team members studied practices in Austria, England, Finland, France, and Germany to learn about new approaches in designing and assessing bridges, such as the use of refined analysis to gain a better understanding of how a bridge behaves under traffic loads.

In October 2009, FHWA became an Associate of the Forum of European National Highway Research Laboratories (FEHRL). This organization brings together more than 30 national research and technical centers in Europe, along with associated institutes worldwide. FEHRL is engaged in a range of road engineering research topics, including safety, infrastructure, operations, environmental issues, and economic evaluation.

A Memorandum of Cooperation (MoC) between FHWA and FEHRL signed in July 2011 provides a strategy for partnership that will extend the reach of individual resources and enhance the quality of the resulting research products, establishing a protocol for collaborating on and jointly funding priority research topics. The MoC will speed the development and implementation of innovations and new highway technologies, enable technologies first identified in Europe to be brought to the United States more quickly, and expand the markets for U.S. technologies. For example, work underway in Europe on reducing pavement friction could be leveraged and brought to the United States with nominal FHWA funding, achieving greater value for the research investment.

R&T Across FHWA

Offices across FHWA are supporting new R&T initiatives and the deployment of innovation.

FHWA plays a critical central leadership role in developing, deploying, and implementing transportation innovations, as well as collaborating with the public and private sectors, academia, and the international community to provide a comprehensive innovation program. In many cases, the Agency acts as a convener, bringing the R&T community together to define priorities and future directions.

FHWA's organizational structure provides a platform that facilitates innovation delivery. With Division offices located in each State, and Local Technical Assistance Program (LTAP) centers located nationally, agency staff can interact directly with State and local governments and help to foster innovation deployment.

The Turner-Fairbank Highway Research Center in McLean, Virginia, is home to more than 20 laboratories, data centers, and support facilities. At the center, approximately 100 staff members, primarily engineers and scientists, conduct and manage applied research to improve the state of the practice and exploratory advanced research to enhance the state of knowledge. They are supported in this work by approximately 200 onsite contractor staff. Areas of expertise and research include safety, infrastructure materials and systems, human-centered systems, vehicle-highway interaction, operations and intelligent transportation systems, and materials. New ideas are at the heart of research in all of these diverse areas, but FHWA's R&T agenda always keeps the end goal in mind as projects move from inception to innovation.

Staff at FHWA's Turner-Fairbank Highway Research Center conduct research in such areas as safety, infrastructure materials and systems, and operations and intelligent transportation systems.

FHWA's Office of Infrastructure provides leadership, technical assistance, and program assistance in the areas of asset management, bridges, pavements, and program administration. Also providing leadership is the office's Highways for LIFE program, which focuses on accelerating the adoption of innovations and technologies. Innovations developed through the Office of Infrastructure include the Pavement Health Track Analysis Tool, which can be used to determine the health of a pavement network in terms of the pavement's remaining service life, based on rideability and pavement distresses.

The FHWA Office of Operations provides national leadership for the management and operation of the surface transportation system, including the areas of congestion management, ITS deployment, traffic operations, emergency management, and freight management and operations. Initiatives include the Localized Bottleneck Reduction Program, which examines the root causes, impacts, and potential solutions to traffic chokepoints that are recurring events. As part of this initiative, the office issued *An Agency Guide on How to Establish Localized Congestion Mitigation Programs* in 2011.

Reducing highway fatalities and injuries is the mission of the FHWA Office of Safety, which works with State and local partners and others in the

A rock cut slope on the George Washington Memorial Parkway in Arlington, Virginia. The innovative use of rock gluing on the Parkway stabilized the rock slopes while preserving the scenic beauty of the Parkway.

transportation community to develop and promote programs and technologies to improve safety. To carry out this mission, the office uses a data-driven, systematic approach that addresses the "4Es" of safety: engineering, education, enforcement, and emergency medical services. Resources include information and guidance on "Nine Proven Crash Countermeasures," such as the Safety Edge, road safety audits, rumble strips, and roundabouts.

FHWA's Office of Policy and Governmental Affairs encompasses the areas of Highway Policy Information, International Programs, Transportation Policy Studies, and Legislative and Governmental Affairs. Initiatives include maintaining the Highway Performance Monitoring System, which includes data on the condition, performance, use, and operating characteristics of the Nation's highways. International activities include the Global Technology Exchange Program, which fosters information sharing and the facilitation of partnering relationships among U.S. States and their counterparts in Africa, Asia, Europe, and Latin America.

The FHWA Office of Planning, Environment, and Realty provides leadership in the areas of comprehensive intermodal and multimodal transportation planning, environmental protection and enhancement, and the fair and prudent acquisition and management of real property. Recent initiatives include the development of a 2011 *Transportation Planning for Sustainability Guidebook*, which examines how sustainability considerations can be better incorporated into transportation planning. The guidebook features case studies highlighting sustainability planning practices at State DOTs.

FHWA's Office of Federal Lands Highway provides program stewardship and transportation engineering services for the planning, design, construction, operation, maintenance, and rehabilitation of the highways and bridges that provide access to and through National Parks and other Federally owned and Tribal lands. The Federal Lands Highway Program (FLHP), which was created by the 1982 Surface Transportation Assistance Act, provides financial resources and technical assistance for a coordinated program of public roads that serves the transportation needs of Federal and Tribal lands. The Federal Lands Highway Technology Program evaluates new highway technology that will improve the quality and efficiency of the FLHP and its delivery systems within the highway community.

The program provides solutions that are sensitive to agency needs, improve agency efficiency, and improve the quality of transportation projects.

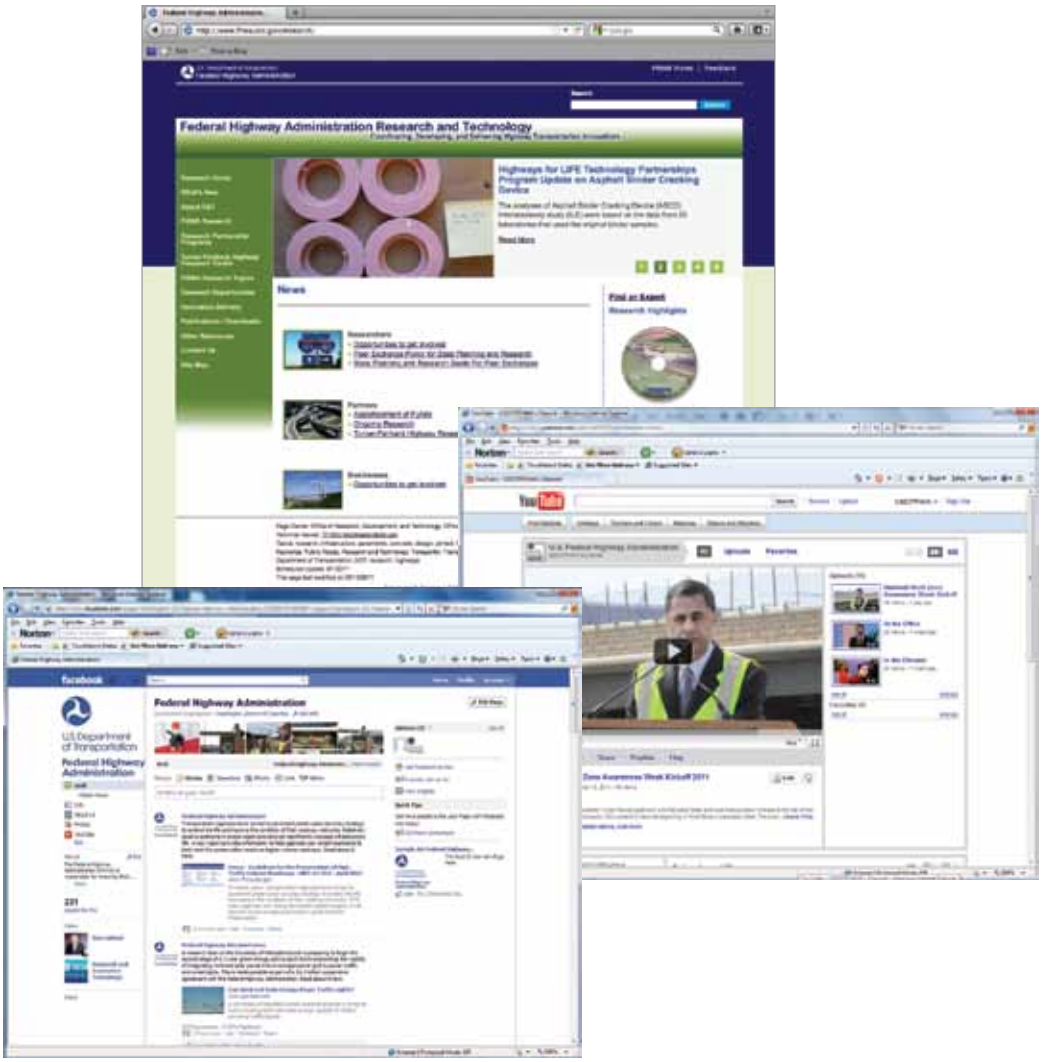
Technology advances deployed through Federal Lands include the innovative use of "rock glue" to stabilize rock slopes on roadways and protect drivers from rockfall hazards, while aesthetically improving the appearance of the rock slope. The technique has been used on the George Washington Memorial Parkway in Virginia and for projects on the Blue Ridge Parkway in North Carolina, the Appalachian Trail in Pennsylvania, and the Great Smoky Mountains National Park in Tennessee.

The Office of Technical Services provides key support to the delivery of technologies and innovations. By bringing together the FHWA Resource Center, National Highway Institute (NHI), and Technology Partnerships Programs under one office, FHWA strengthened its ability to deliver vital services more strategically. The Resource Center and its Technical Service Teams facilitate technology deployment and technical assistance, NHI provides critical training opportunities, and the Technology Partnerships Programs offer education and local and tribal technology assistance.

The Technical Service Teams provide expertise and innovative technical assistance to help State and local agencies successfully adopt and deploy new technologies in such areas as construction and project management, finance services, operations, pavement and materials, safety and design, and structures. The work of the teams is bolstered by NHI, which offers more than 300 courses across 17 program areas to advance the performance of the transportation workforce. A growing number of courses are available online, meeting the need for training even as State and local agencies face tighter budgets. Partnerships are also key, as the Technology Partnerships Programs support the training, technical assistance, and technology deployment efforts of the LTAP and Tribal Technical Assistance Program centers. The program also works with international partners to support professional development and technology transfer.

The R&T Story Continues

As FHWA prepares for future challenges, the R&T story continues to evolve. To learn more about the array of initiatives underway, including details on new research projects, technology deployment, opportunities for partnerships, and plans for the R&T future, visit www.fhwa.dot.gov/research today. The Agency's new Facebook page and YouTube channel also offer opportunities to learn about all things FHWA, including current news items, new technologies and initiatives, ongoing programs, and recent events. Check out FHWA's Facebook page at www.facebook.com/pages/Federal-Highway-Administration/175380479155058. To view FHWA's YouTube channel, visit www.youtube.com/user/USDOTFHWA.



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