Public Roads

www.fhwa.dot.gov

July/August 2010

U.S. Department of Transportation
Federal Highway Administration

Invasive Plants
Complete Streets
IntelliDrive

Public Roads

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

July/August 2010 www.fhwa.dot.gov Vol. 74, No. 1

Articles

Transportation Lessons From Central Europe
by Daniel J. Berman 2

FHWA and Rhode Island highway officials visited the Czech Republic and Poland to share technology, policies, and practices.

Are We Winning or Losing the War on Weeds?
by Mary Ann Rondinella and Bonnie L. Harper-Lore 8

The attack of invasive plants on the Nation's roadsides is still ongoing, but emerging alliances and their successful strategies are on the counterattack.

Complete Streets *by Robin Smith, Sharlene Reed, and Shana Baker* 12

From policy statements to programs and planning, opportunities abound for improving the accessibility of the transportation system for all users.

IntelliDrive! *by Shelley J. Row* 18

USDOT introduces a new strategic plan for multimodal ITS research that aims to produce safer, interconnected, and more convenient travel.

From Hot to Warm *by Matthew Corrigan, Dave Newcomb, and Thomas Bennert* 23

FHWA and its partners continue to advance warm-mix asphalt, which can cut production costs and emissions and still provide long-lasting pavements.

Scour, Flooding, and Inundation *by Kornel Kerenyi and Junke Guo* 30

The FHWA hydraulics R&D program conducts advanced and applied research to mitigate disaster risks by addressing three of the main hazards.

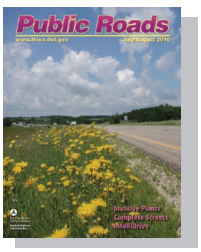
Page 2

Page 12

Page 18

Departments

Guest Editorial 1
Along the Road 36
Internet Watch 39
Training Update 40
Communication Product Updates 41
Conferences/Special Events Calendar 44



Front cover—Perennial or field sowthistle, *Sonchus arvensis*, spreads naturally by rhizomatous roots. Here, along the edge of a Midwestern interstate, mowing practices are likely to spread this invasive farther. Some 14 States have placed sowthistle on their noxious weed lists, requiring control, but in the roadside environment, only chemical treatments are effective. For more information, see "Are We Winning or Losing the War on Weeds?" on page 8 in this issue of PUBLIC ROADS. *Photo: Bonnie L. Harper-Lore.*

Back cover—A colorful mosaic of invasive plants greets and might please travelers on this interstate. The highway maintenance district views it differently. Each invasive species requires a different control strategy, both in timing and method. The mosaic includes Canada thistle, spotted knapweed, common tansy, musk thistle, common toadflax, perennial sowthistle, with yellow and white sweetclovers. *Photo: Bonnie L. Harper-Lore.*

U.S. Department of Transportation
Federal Highway Administration

U.S. Department of Transportation
Ray H. LaHood, *Secretary*

Federal Highway Administration
Victor Mendez, *Administrator*

Office of Research, Development, and Technology
Michael Trentacoste, *Associate Administrator*

Martha Soneira, *Editor-in-Chief*

Paula Magoulas, *Publication Manager, Creative Director*

Norah Davis, *Editor*

John J. Sullivan IV, *Associate Editor*

Martha Soneira, *Distribution Manager*

Editorial Board
J. Paniati, chairman; J. Baxter, J. Curtis, D. Elston, K. Gee, J. Lindley, A. Lucero, A. Masuda, R. McElroy, P. Prosperi, G. Shepherd, J. Toole

Public Roads (ISSN 0033-3735; USPS 516-690) is published bimonthly by the Office of Research, Development, and Technology, Federal Highway Administration (FHWA), 1200 New Jersey Avenue, SE, Washington, DC 20590. Periodicals postage paid at Washington, DC, and additional mailing offices.

POSTMASTER: Send address changes to *Public Roads,* HRTM, FHWA, 6300 Georgetown Pike, McLean, VA 22101-2296.
The editorial office of *Public Roads* is located at the McLean address above.
Phone: 202–493–3468. Fax: 202–493–3475.
Email: martha.soneira@dot.gov.

Public Roads is sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Requests for subscriptions should be sent directly to New Orders, Superintendent of Documents, P.O. Box 979050, St. Louis, MO 63197-9000. Subscriptions are available for 1-year periods. Paid subscribers should send change of address notices to the U.S. Government Printing Office, Claims Office, Washington, DC 20402.

The electronic version of *Public Roads* can be accessed through the Turner-Fairbank Highway Research Center home page (www.fhwa.dot.gov).

The Secretary of Transportation has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this department.

Guest Editorial

Putting FHWA in Its Global Context

The recent global recession has left little doubt about the connections among economies worldwide. Efforts undertaken in response have demonstrated the contributions that transportation, especially roads, can make to restoring economic vitality. Here in the United States, using funding provided under the American Recovery and Reinvestment Act of 2009, the Federal Highway Administration (FHWA) is helping State departments of transportation create new jobs and advance much-needed road and bridge projects nationwide. Meanwhile, road administrations in other parts of the world also have mobilized to improve transportation networks as a way to support near-term and long-term economic growth.

The similarity of the challenges facing FHWA and its international counterparts and the urgency of their responses based on economic and other imperatives are striking. And considering the transnational nature of some of the issues facing the world—economic stimulus, safety, climate change, sustainability, efficiency—it's important to look at what FHWA is doing in a global context.

For some time, FHWA's overseas outreach has used the International Technology Scanning Program and other information exchange missions to better understand technologies and practices that have the potential to favorably impact highway transportation in the United States. These programs have proven valuable in a number of areas, some of which relate to the topics covered in this issue of PUBLIC ROADS. For example, in 2007, FHWA organized a scan to survey several European countries' use of warm mix asphalt; the article "From Hot to Warm" (page 23) reports on continuing work linked to that study. Similarly, less formal information exchange activities in Poland and the Czech Republic have revealed practices of potential value to the United States, as described in "Transportation Lessons From Central Europe" (page 2).

Another aspect of FHWA's international program involves sharing U.S. expertise in support of other countries' efforts to develop, enhance, and maintain effective and efficient road networks. Transportation agencies in the United States and their peers in other countries encounter a range of issues—from creating new capacity to maintaining existing infrastructure to adapting road networks to changes in the natural or human environment. These issues are all areas in which FHWA has and continues to develop a strong knowledge base. In establishing relationships to exchange information, FHWA helps to resolve transportation issues that have impacts beyond any single set of borders. Just as important, the flow of knowledge often works in reverse too, bringing new ideas back home.

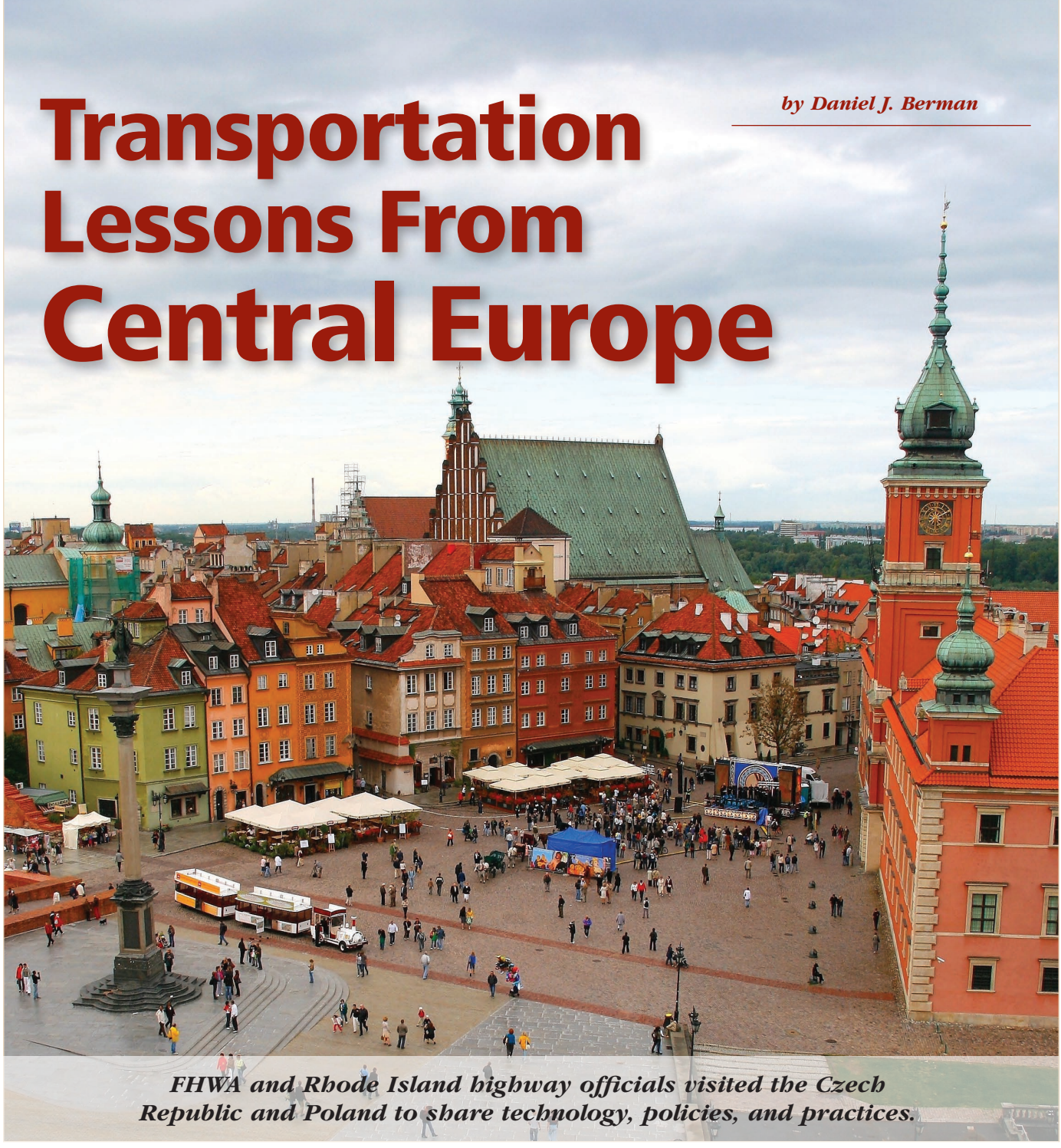
This issue of PUBLIC ROADS touches on several other issues of worldwide import: Support of intelligent transportation systems to improve safety and combat congestion can help satisfy global health and economic objectives. Demonstrating measures to mitigate flooding damage to infrastructure is critical in the context of changing weather patterns around the world. And sharing ideas to make transportation more accessible makes sense in any country—perhaps especially in developing areas where motorized and nonmotorized modes of transport compete for safe use of roadway facilities or in developed countries where driving populations are aging.

The challenges facing the road sector are many and complex. But the link between roads and the economy is clear. By remaining aware of the global setting in which FHWA operates and by engaging with international partners, the agency will continue to make mutually beneficial exchanges possible and help address some of the most pressing issues confronting the U.S. and global highway community.

Ian C. Saunders
Director, Office of International Programs
Federal Highway Administration

Transportation Lessons From Central Europe

by Daniel J. Berman



FHWA and Rhode Island highway officials visited the Czech Republic and Poland to share technology, policies, and practices.

The Rhode Island Department of Transportation (RIDOT) recently collected and analyzed more than 10 years of historical data on crashes and found that alcohol, speeding, and failure to use seatbelts represented a disproportionate share of safety problems. In fact, speeding accounts for 52 percent of all road fatalities in Rhode Island, about 20 percent higher than the national average.

Halfway around the world, Poland faces a similar challenge. In 2008, Poland saw 67,534 roadway casualties, including 5,437 deaths and 62,097 injuries. Crash rates are twice as high in Poland as in Western European countries. As one approach to addressing the problem, the Polish Road and Bridge Research Institute is looking to its peers for ways that could help engineers take appropriate steps to improve safety. Innovative new technology was among several practices and policies that a contingent of U.S. transportation officials learned about firsthand during an April 2009 visit to Central Europe.

The U.S. officials traveled to Poland and the Czech Republic to participate in meetings, roundtable discussions, and site visits. They made the trip under the auspices of the Federal Highway Administration's (FHWA) Office of International Programs (OIP), which supports the exchange of road transportation technologies

(Above) FHWA and Rhode Island highway officials visited Warsaw, Poland's old town pedestrian square (shown here from above) during a recent trip to Central Europe to share transportation policies and practices. *Photo: Shutterstock.com, Aneta Skoczewska.*

and facilitates partnering (or "twinning") relationships between States and foreign governments. One of OIP's goals is to facilitate information and technology exchange among U.S. and global partners to improve the highway transportation systems at home and abroad.

The trip was coordinated through OIP's Central European Technology Exchange (CETE) program, which promotes technology exchange, research, and workshops on issues of mutual interest to the United States and its partners in the Czech Republic, Hungary, and Slovakia. The study team included representatives of RIDOT, FHWA's Rhode Island Division and its Resource Center's Safety and Design Technical Service Team, and the Rhode Island Technology Transfer (T^2) Center located at the University of Rhode Island. (Other U.S. members of CETE are the Texas Transportation Institute and Virginia Transportation Research Council.)

"Working with the Central European Technology Exchange program . . . has provided opportunities for the CETE partners to not only share cutting-edge technology with each other, but to also be involved in innovative research that helps to improve the safety of roads in our Nation," says Ian Saunders, director of OIP.

The United States has longstanding and mature transportation relationships with many European countries. Broadening and deepening these partnerships remains a key focus for FHWA. The Central European highway agencies offer U.S. practitioners opportunities for learning, networking, and benefiting from successful programs in transportation management in partner countries.

"The advent of globalization and new market economies has crystallized the reality that important issues facing development, improvement, and management of complex transportation systems are not exclusively a State, regional, or national concern," says Phillip Kydd, RIDOT's assistant director. "Rather, ensuring that people and products can move effectively and efficiently in our global society has become an international priority."

During the April 4–11, 2009, peer exchange, the U.S. officials traveled to Warsaw, Poland, for meetings; toured laboratories there and in Tišnov, Czech Republic; and met with Czech Ministry of Transport officials in Prague. Topics of discussion included developing programs and procedures to strengthen international partnerships and linkages, implementing safety management tools that support national planning and programming decisions, using workforce development programs to support engineering careers, linking countries and cities with high-speed rail, and improving automobile recycling practices to support sustainability goals.

Tour Objectives

The primary objective of the study team's visit was to work with Poland to help it become part of CETE and learn about technology transfer activities from members in the United States and Central Europe (Czech Republic, Hungary, and Slovakia). The team then was to identify and bring home any best practices concerning safety programs, regulatory standards, and transportation policies.

The second objective was to meet with Czech and Polish officials to discuss potential joint venture partnerships. The representatives discussed high-speed rail development in the central European Union (EU), road safety research projects in the Czech Republic, and implementation of workforce development programs.

The third objective was to meet with officials at the Czech Republic's University of Ostrava to finalize arrangements for a 2009 Summer Transportation Institute. Partnerships for creating international peer exchanges will help universities produce a diverse, globally engaged science and engineering workforce to staff U.S. departments of transportation (DOTs). The institute also aims to catalyze cultural change within State DOTs by establishing innovative new models for international collaboration.

Polish Transportation Policy

Poland is home to 38.5 million residents and covers an area slightly smaller than New Mexico. It is the ninth largest country in Europe, at 120,728 square miles (312,685 square kilometers). Poland is also a success story: After the breakup of the Soviet Union in the 1990s, it became a robust Central European economy. In 2008 gross domestic product (GDP) grew an estimated 4.8 percent, based on rising private consumption, a jump in corporate investment, and EU fund inflows.

In October 1994, Poland's Ministry of Transport and Maritime Economy prepared a document titled *Transport Policy*. The policy was an action plan aimed at transforming transportation in line with a market

Jeff Cathcart, Rhode Island T² Center

This horse and buggy are for tourists in Warsaw, but much of the Polish transportation system is slated for modernization.

Jeff Cathcart, Rhode Island T² Center

Traffic management practices, as on this freeway in Warsaw, were among the topics discussed during the visit.

economy and economic cooperation in Europe. Poland requires major investments in transportation infrastructure, including motorways, as its economy continues its rapid growth.

A new government came into office in 2007 and announced intentions to enact business-friendly reforms and accelerate privatization. The government's plan is to develop a US$10.1 billion program of public-private partnerships to build an "interstate-style" highway system across Poland. Government officials also announced plans for a high-speed rail system. In addition, with road crashes becoming a leading cause of death in Poland, program planners need further analysis of the causes of the crashes and cost-effectiveness of various remedial measures.

Complicating the issue, the EU allows heavier trucks than are permitted in Poland. According to Polish transportation officials, if main roads are to be strengthened to accommodate trucks up to EU weight limits, Poland's investment budget will need to double allocations for road rehabilitation. Poland's transportation policy notes that the country must form international linkages and partnerships to reach its goals of safety, sustainable development, economic growth, and ecological and public health.

International LTAP

The CETE meeting provided an opportunity for the U.S. team to begin forging new partnerships with the Central European countries. In each city visited, the hosts revealed that training for public employees is a common concern. A younger emerging workforce will need basic transportation skill sets as they replace an aging public works workforce. During and after the meetings, attendees provided insights into their own practices and the factors that have contributed most to their success. For example, road safety audits commonly used in the United States now are becoming a valuable tool in the Central European countries. Another example is Rhode Island's winter maintenance and snow plow training.

Polish officials discussed their country's interest in developing Local Technical Assistance Program (LTAP) centers for their own cities and towns. Participants described examples of typical LTAP activities and what training courses could be offered using Web-conferencing technologies. Both Rhode Island and the Czech Republic identified the steps necessary to establish a center.

"The LTAP/TTAP [Local Technical Assistance Program/Tribal Technical Assistance Program] has had wonderful exchanges with international agencies and their professional employees for many years," says Mike Burk, director of FHWA's Technology Partnership Programs. "There is so much to learn from each other related to how our road systems are planned, designed, constructed, and maintained."

The Czech Republic's LTAP activities are similar to those in the United States, but its customers are different and more diverse, such as including a research element. CETE, which includes the Czech Republic, Hungary, and Slovakia, has a much broader customer base with both contractors and educators included. The European LTAP model has its roots in the transportation research centers in each country. Each center undertakes technology transfer and works with educational improvement programs and training.

Based on discussions during the tour, Polish officials currently are forming an LTAP center, with technical support from the Rhode Island T² Center. As part of this support, the U.S. partners share best practices during quarterly teleconferences coordinated by OIP. In addition, a Polish representative visited the Rhode Island T² Center and participated in the LTAP/TTAP New England regional meeting in May 2009.

Collaborative Safety Initiatives in Central Europe

Facilitated by FHWA, RIDOT and the Rhode Island T² Center already had worked with the Central European T2 partners on several projects. One was the SnowFlake Road Safety Project, jointly funded by FHWA and the Czech Republic, organized by the Czech CDV (Czech acronym for what translates to Transport Research Center) in Brno and studying both Central European countries and U.S. States (the Czech Republic and Rhode Island in particular). That study drew on the European Union's SUNflower project, in which 15 countries tried such approaches as raising the legal driving age to 21 and imposing penalties for failure to wear seatbelts, which resulted in greater road safety. From a public policy perspective, the SnowFlake data could be used to develop more effective safety programs and tools.

At the April 2009 Central European T2 meeting, the partners discussed the findings of the SnowFlake project. They agreed to continue the study by adding Connecticut, Massachusetts, Texas, and Poland to the roster of States and countries being analyzed. The purpose of the study is to compare safety attributes and policies to identify best practices. Poland is working with the Krakow (Cracow) University of Technology's Road and Traffic Engineering Group to provide the needed data.

The U.S. team discussed with its hosts several other new studies during its visit to Brno, including the black box project. Developer CDV and the Central European T2 countries are using black boxes to collect more accurate statistics on crashes, with the goal of improving safety.

The black boxes record, store, and export data from automobiles. Rather than duplicate or add to vehicle instrumentation, however, CDV designed the device to collate information, such as speed and geographic location, already being recorded by vehicle sensors. Researchers believe the black boxes have the potential to curb drunk driving and otherwise modify driver behavior (a drinker might be reticent to drive if he knows the device in his car can show he was parked at a bar for a long time).

CDV recently installed a black box in a police car and found other benefits as well. For instance, the device can electronically load much of the information, such as crash location and weather conditions, into police reports, a task that otherwise would have required writing or typing by hand. The study team is interested in applying the black box project in Rhode Island. The idea is to look at how this technology might work if applied in the United States.

Also of interest to Rhode Island, CDV is developing an intelligent transportation systems (ITS) approach to zip merging. Zip merging refers to lane shifting in work zones, where vehicles in the right-most lane, say, have several hundred yards to merge into the lane on their left before encountering a lane closure for work on the right-hand shoulder.

A trailer-borne dynamic zip management system will inform drivers when to merge fluidly without reducing their speed and interfering with drivers in the continuous lane. The system will depend on real-time traffic flow monitoring and interpretation of speed and flow-rate data. Halogen navigation arrows, which can be supplemented with light-emitting diode boards, static signs, flashing lights, and other assets, will operate based on that interpretation and display the ideal merging spots.

The system will encourage drivers to use both lanes up to the closure point in times of heavy traffic volumes. In this case, an animated message would appear telling drivers to merge ahead of the lane closure. Road managers expect that by displaying this information the ideal zip-merging model will happen automatically based on speeds and congestion.

If the flow rate of the lane is low or medium and stable traffic speed is detected, the system will notify drivers of the work zone using the general message sign. The flashing lights and arrow symbols, along with a short message, will advise drivers to merge fluidly into the continuous lane.

"This traffic-calming approach has evolved into a cooperative project in which RIDOT will conduct a demonstration project of the recently tested zip-merge traffic system from the Czech Republic," says RIDOT's Kydd. That project is set to begin in 2010.

Daniel J. Berman, FHWA RI

This acoustic noise measurement trailer is among the emerging technologies the Czech Republic is employing to improve transportation. The device measures tire noise on different types of pavements and therefore helps engineers develop quieter pavements.

Workforce Development In Central Europe

In the Czech Republic, where the transport sector creates almost 9 percent of the nation's GDP (as of 2008) and employs about 5.5 percent of the working population in the civil sector of the economy, workforce development is critical.

FHWA, RIDOT, and the Czech Republic are linking academic activities and opportunities to enable students to experience some of the international aspects of transportation and develop skills and the confidence necessary to address global challenges. The goal is to expose students to the transportation industry and help them develop skills needed by a diverse, well-qualified workforce for the 21st century. For example, one approach builds on

Daniel J. Berman, FHWA RI

This zip-merging display trailer is among the emerging technologies the Czech Republic is testing to manage traffic and reduce congestion.

Daniel J. Berman, FHWA RI

EU funding helped Poland purchase this equipment for its national concrete laboratory.

FHWA's National Summer Transportation Institute, a career awareness initiative designed to introduce secondary school students to transportation-related careers, provide academic enhancement activities, and encourage students to pursue transportation-related courses of study at the college and university level.

The Czech Republic held its first international summer transportation institute in summer 2009 at the VSB-Technical University of Ostrava. The U.S. partners helped their Czech Republic counterparts plan the institute and participated via videoconference in an event that involved RIDOT interns and Czech students. The Czech Republic and Poland in turn participated by videoconference in Rhode Island's summer transportation institute in 2009.

"The U.S. students were amazed that people on the other side of the world had similar needs and were working on similar projects," says Jeff Cathcart, director of the Rhode Island T² Center. "The international LTAP program makes the world a small place."

Europe's High-Speed Rail Programs

High-speed rail (HSR) systems now operate in several countries, including France, Great Britain, and Japan. The Europeans define high speed as 125 miles per hour, mi/h (201 kilometers per hour, km/h) or more, but speeds over 79 mi/h (127 km/h) meet the definition in the United States. Poland and the Czech Republic propose building extensive new networks by 2015. In 2008 the Polish government's high-speed rail committee approved a draft policy document and environmental impact study for development of HSR services. In the United States, several State and local governments, as well as private sector groups, have undertaken feasibility studies to assess the potential for high-speed passenger rail technology.

In the United States, Amtrak's Northeast corridor main line (linking Boston, MA; Providence, RI; New York, NY; Washington, DC; and intermediate cities) is the Nation's most highly developed high-speed rail line. The project had its roots in the High Speed Ground Transportation Act of 1965 and was shaped by railroad restructuring legislation in the mid-1970s. In the 1980s, the Federal Railroad Administration and Amtrak undertook a major overhaul and improvement of the system. Called the Northeast Corridor Improvement Project, the overhaul included safety upgrades, modernization of the signaling system, and new control centers in Boston, New York, and Philadelphia. The project enabled more trains to run faster and closer together, and set the stage for later high-speed operation.

During the Central European T2 meeting, participants discussed the potential for using an asphalt base for high-speed railroads in the United States and Central Europe. Rather than construct the track so that it "floats" within a ballast bed, crews place the track on top of an asphalt slab that can provide ride comfort, low maintenance costs, and a long life.

The Czech Republic has a long history of providing courses on railroad engineering. In the United States, where there has been limited construction of new rail capacity in recent decades, the subject is emerging as a new skill set for engineering students. RIDOT and the Rhode Island T² Center are interested in developing a civil engineering course on high-speed rail systems. At the Central European T2 meeting, their representatives discussed the possibility of jointly developing a seminar with officials from VSB-Technical University.

Sustainable Communities And the Environment

The study team and its hosts also discussed innovative ways of promoting sustainable communities, including managing waste and using legislation to encourage recycling cars, such as through the U.S. Cash for Clunkers program. One field with potential in the United States is recycling glass for use as aggregate and backfill. Hungary has done extensive work in this field and has a state-supported plant to produce the glass aggregate. Germany has several private plants, and the Czech Republic has one.

Manufacturers recirculate waste glass to produce granulated foamed glass. The normal grain size is 0.4–2.4 inches (10–60 millimeters). With its insulating properties, light weight, and compactability, foamed glass can serve as fill material, as a

Daniel J. Berman, FHWA RI

In Warsaw, FHWA and CETE representatives examine a van outfitted with sensors and equipment to measure the condition of pavement surfaces.

Jeff Cathcart, Rhode Island T² Center

Central European countries routinely use colored asphalt pavement, as seen in these samples in Warsaw.

frost protection layer in roads, or in other civil engineering applications.

Hungary has experienced problems, such as water intrusion, pumping, and faulting, with asphalt layers placed beneath portland cement concrete pavements. The country has evaluated using foamed glass to provide better drainage and prevent these problems. The foamed glass has been used as a base course for pavements and as backfill on some projects and has been shown to provide better drainage. The Rhode Island T² Center will work with its resource recovery agency to evaluate the potential for manufacturing foamed glass from its waste stream and for using the glass in highway construction.

The study team and hosts also discussed use of colored synthetic asphalt pavements. Poland and other European countries use colored asphalt in bicycle lanes, crosswalks, and bus stops. "It is the best product for delineating an area of a road," says Professor Dariusz Sybilski, Road and Bridge Research Institute of Poland. "The color reduces the need for striping and thus helps delineate lane width, minimizes maintenance, and maximizes wet-skid resistance." The Rhode Island T² Center and Poland are collaborating on a joint project involving colored asphalt. They plan to try the color contrasting asphalt in high-risk safety areas such as left-turn lanes at intersections.

Outlook

Among the most important findings from the trip, according to the study team, is the importance of working together on crosscutting issues such as safety and operations. For example, the United States could easily implement work zone zip-merging signs that graphically depict alternating traffic.

The concept of "global engineering" also rose to the top. Global engineering effectively breaks down and distributes large, complex tasks among global participants, thereby expediting innovation and development. Practitioners can exchange information during CETE meetings and videoconferences, and share results with agencies that are unable to attend.

Each U.S. official who participated in the trip identified opportunities within his or her discipline and developed a working relationship with a Central European contact. "CETE creates an outstanding base, inspiring framework, and cultivating network for cooperation between the United States and Central European countries sharing best practices, advanced experience, and new knowledge in transportation," says Josef Mikulik, institute council chair, CDV, in the Czech Republic. "That brings mutual benefits for all participating partners. CETE clearly demonstrates the possibilities and contributions of transatlantic partnerships."

Cooperation has the potential to improve transportation policies at the State and national levels.

"In an age of advanced technologies and global logistics, we should continue to be open to the idea that some of the most pressing issues that affect our national transportation systems may indeed have answers in the approaches of our European partners," says RIDOT's Kydd.

Or, as FHWA's Burk puts it, "Why should we all reinvent the wheel when we can learn from each other? We all have the same goal of a safe and efficient highway network."

Many other parties also see promise in cooperation like that of Rhode Island and the T2 countries. As the National Academy of Sciences stated in its report *Interacademy Programs Between the United States and Eastern Europe 1967–2009: The Changing Landscape*, "Eastern Europe [including the Czech Republic, Hungary, and Slovakia] is a unique cluster of middle-income countries with strong scientific capabilities in a number of important areas and with a long history of scientific interchange with the United States that unfortunately was disrupted for nearly one-half century. The legacy of scientific and educational excellence throughout the region is strong, and the desire to strengthen partnership with U.S. colleagues is omnipresent."

Daniel J. Berman has worked for FHWA for 35 years in transportation engineering and planning, at the regional level and in State division offices. In his current position as assistant division administrator for the FHWA Rhode Island Division, he coordinates FHWA's policies with State officials and serves as the division focal point for technology transfer and strategic planning.

For more information, contact Daniel J. Berman at 401-528-4560 or daniel.berman@dot.gov or Ian Saunders, director of OIP, at 202-366-0111 or ian.saunders@dot.gov.

Are We Winning or Losing the War on Weeds?

by Mary Ann Rondinella and Bonnie L. Harper-Lore

The attack of invasive plants on the Nation's roadsides is still ongoing, but emerging alliances and their successful strategies are on the counterattack.

On the day you read this article, another 4,600 acres (1,863 hectares) of public lands will be invaded by weeds, according to a Bureau of Land Management and Utah State University estimate. In addition, since the September/October 2002 publication of a PUBLIC ROADS article on the "war on weeds," a number of new species have spread along the Nation's roadsides. Among the new invaders are cogongrass, Japanese stiltgrass, wavyleaf basketgrass, and Chinese silvergrass.

Research shows that weedy species along roads are directly correlated to plant invasions of adjacent lands. Invasions of weeds degrade habitat, threaten diversity, replace rare native plants, increase erosion, facilitate wildfires, and usurp water resources. The consequences of a failure to win the war on weeds include fewer songbirds, more ranchers out of business, fewer pollinators, lower food production, less wildlife habitat, more loss of recreation, loss of flood control, and loss of water in the West.

Typically, weedy grasses and shrubs go unnoticed by the traveling public. Even for vegetation managers, weeds often are difficult to differentiate from native or other beneficial plants. Without public awareness and increased training for managers, the ecological and economic losses will continue to escalate. In 2004, the impact of invasive species in the United States was estimated at $142 billion per year.

Moreover, although the overall effects of climate change are uncertain, longer growing seasons and more severe droughts could exacerbate the spread and persistence of some weed infestations. For example, a *Pennsylvania Climate Impact Assessment* published by the Pennsylvania Department of Environmental Protection notes that warmer temperatures may increase the persistence of invasive plants previously killed by cold winters. Kudzu, intentionally planted as an ornamental, formerly was believed unable to survive Pennsylvania winters. But now kudzu stands are in fact persisting, although not expanding. Pennsylvania has begun an eradication program.

In the face of a changing environment and uncertainties associated with that change, the national strategy of early detection and rapid response is still the best overall approach to combat invasive species. State departments of transportation (DOTs), however, face challenges in waging that battle.

In 2006, the National Cooperative Highway Research Program issued NCHRP Synthesis 363, *Control of Invasive Species*. The synthesis identifies a number of challenges, with lack of funding being the principal one. Not surprisingly, 53 percent of State DOTs responding to the survey conducted for NCHRP Synthesis 363 stated that lack of State funding was an obstacle for invasive species control. Thirty-eight percent cited limited Federal funding as a primary obstacle. Many also mentioned limited staffing and lack of dedicated personnel as obstacles. Overcoming these challenges in a time of limited resources and building on gained experience will be crucial to making progress in the war.

Executive Order 13112, signed in 1999, requires Federal agencies to prevent and control invasions of nonnative plants. According to the executive order, Federal-aid dollars can no longer be used to cause further introductions. In 2005, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) expanded eligibility for Federal funding for control of invasive species and environmental restoration. It did not, however, create new funding sources.

The Federal Highway Administration (FHWA) has provided research funding for affordable global positioning system (GPS) units and weed washers, plus technical support via field guides, newsletters, and workshops to inform State DOTs about control of weeds on the ground.

(Above) Facing constrained budgets, DOTs have reduced mowing and spraying applications, allowing aggressive weed species such as this spotted knapweed to flourish in some areas. *Photo: Bonnie L. Harper-Lore.*

FHWA also has crafted a National Environmental Policy Act (NEPA) process to assess the potential impacts of any action on invasive species. Meanwhile, States continue to be under pressure from adjacent public and private landowners, as well as State noxious weed laws and county weed boards, to increase best practices and do more with less.

On the other hand, the good news is that agencies, communities, and conservation groups are creating alliances across the country and developing strategies to increase awareness of the dangers of invasive species and ultimately counteract the weed attacks. These emerging alliances have learned that no one entity can win alone. After all, weeds do not respect political boundaries. Roads and highways connect or cross public and private lands, giving transportation agencies a unique responsibility in this battle.

Partnerships as Part of the Answer

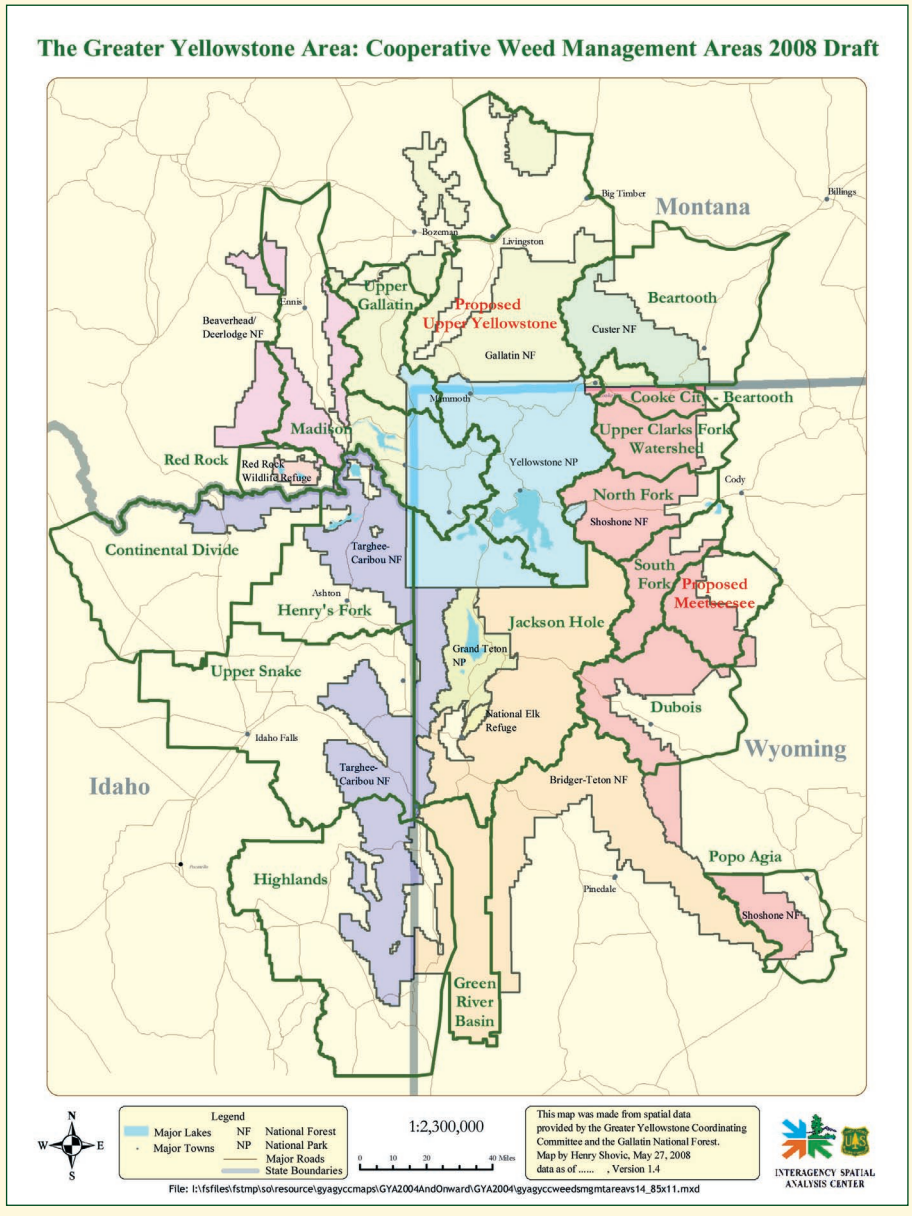
A few examples at various levels of government illustrate the point that partnerships are especially important to increasing public awareness and thus helping to prevent the spread of weeds.

International-DOT partnership. In 2002, the Washington State DOT joined with counterparts in Okanogan County, WA, and British Columbia to sign a memorandum of understanding (MOU) to work together in weed prevention and control. The partners include invasive plant councils, local DOTs, counties, and university extensions from both sides of the border. Together, these groups have produced calendars, field identification guides, and signage. Each year, the partners invite policymakers, the media, landowners, and the public on border-crossing tours to increase awareness about the obstacles and opportunities related to controlling invasive plants across international borders. FHWA provided funding for this partnership.

Statewide cooperation. In Oregon, statewide efforts are showing impressive results, as reported by Tim Butler, supervisor of the Oregon Department of Agriculture's Noxious Weed Control Program, in a 2009 press release. One example of the State's notable success occurred in southwestern Oregon where a partnership of State, local, and tribal governments, along with private landowners, eradicated an infestation of more than 300 acres (122 hectares) of a weed called Paterson's curse soon after it was detected in 2004. The weed now is considered 90 percent contained.

Indian Nation-DOT partnership. In 2009, the Minnesota Department of Transportation (Mn/DOT) and the Fond du Lac Band of Lake Superior Chippewa in northeastern Minnesota signed the first MOU with an Indian Nation to reduce chemical use, conduct an inventory of vegetation, and control invasive plants along State highways within the reservation's boundaries. Mn/DOT and the Indian Nation invested many months to build trust and common ground. In 2009, FHWA recognized this partnership as a joint Exemplary Human Environment Initiative/Exemplary Ecosystem Initiative.

Adirondack Park-DOT partnership. In 2002, the New York State DOT, the Adirondack Park Agency (APA), and many State agencies and conservation groups signed an MOU to control four invasive plants in the park and prevent future invasions. A geographic information system (GIS)-based plant inventory created a baseline for control methods used



National Park Service

Dividing the greater Yellowstone area into manageable units based on ground conditions and weed invasions helps landowners and agencies coordinate weed control across millions of acres. Each shaded area represents a multijurisdictional public-private partnership to control weeds.

Best Management Practices

Whenever soils are disturbed during road maintenance or construction, the spread of invasive noxious weeds can result. Disturbances such as flooding, slope failures, or wildfires are beyond the control of DOTs, but the following practices can help avoid those disturbances that DOTs *can* control:

1. *Educate crews and contractors.* The fundamental best practice is to train crews and contractors before any work begins so that they can identify weeds and control them.
2. *Preserve existing native remnants.* The least expensive practice is to disturb as little vegetation and soil as possible when working on a project. This practice also saves time and materials.
3. *Eradicate before construction*. Control weeds before project equipment moves into a site. This preemptive work minimizes the potential of weed spread during the entire construction project.
4. *Certify sand and gravel pits*. Inspecting the pits in advance of a project allows for control of existing weeds and seeds before the pits are used.
5. *Certify weed-free mulch*. Some 20 States already require contracts to specify the use of weed-free forage and mulch. This practice is one of the best ways to avoid spreading invasive plant seed.
6. *Use existing topsoils to create berms.* Rather than importing topsoils potentially containing weed-seed banks, use existing topsoils to create berms along the perimeter of the project for later seeding.
7. *Temporary seeding*. When a project ends at a season that is inappropriate for final seeding cover, use a temporary weed-free annual seeding for later replacement.
8. *Prequalify seed sources*. To help agencies and contractors secure scarce seed, some States prequalify a list of approved seed sources.
9. *Minimize scalping and dredging of soils*. Avoid scalping during mowing or ditch cleaning. If this kind of damage does occur, plant native grasses immediately.
10. *Clean equipment*. Before moving to or from a maintenance or construction site, clean your equipment to minimize weed spread. Remove hanging debris and wash mud from undercarriage, tires, etc.

on common reed, Japanese knotweed, purple loosestrife, and garlic mustard. These activities led directly to the APA issuing a general permit for control practices that previously required lengthy reviews, public comment periods, and individual permits. This effort has successfully kept these four target species from proliferating in the park.

Statewide-DOT partnership. In 2008, the Georgia DOT signed a statewide, private-public sector MOU to unite in an effort to prevent and control the spread of cogongrass in Georgia. This action escalated the war on weeds to a much higher level. In 1911, this aggressive grass was introduced accidentally in packing materials in another southeastern State. Later, it was planted purposefully as forage and became invasive to some 500,000 acres (202,500 hectares) in the Southeast, where it contributes to hot and fast wildfires. By focusing the resources of a partnership on a single invader, Georgia's approach could be a model for adjacent States for an all-out attack on cogongrass.

Additional Successful Approaches

What is needed to help ensure that the war will be won? In NCHRP Synthesis 363, State DOTs stated that documenting the costs and benefits of controlling invasive species is critical to obtain personnel and funding resources. Also, prevention and prompt control are essential to hold down long-term costs.

Based on detailed cost data from a control effort for tall whitetop, researchers from the University of Nevada conservatively estimated that delaying control for 6 years would double costs in the best-case scenario and more likely triple them due to rapid spread of this noxious weed. Many other invasive weeds show the same ability to expand rapidly if left untreated.

Training also is critical. The California DOT (Caltrans) began hosting workshops in 2005 to train crews to inventory the locations of more than 125 weeds that threaten the State's economy and ecology. The Utah DOT offers an annual training academy that has resulted in early detection of invasives that cross the State's borders.

State DOTs also can benefit from sharing information about innovative practices. For example, the use of controlled grazing by goats and sheep is a documented, low-cost, and low-impact way to control invasive species. The Wyoming DOT estimates that maintaining land grazed by sheep costs $18.80 per acre, compared to $185 to $310 an acre using herbicides, and $350 an acre using hand-cutting and mowing. Private contractors are now providing grazing services using goats specifically raised for controlling weeds.

The Wyoming DOT and county partners use an integrated weed management system so that the agency has the lowest herbicide expenditures of any DOT in the United States, while managing a 7,000-mile (11,265-kilometer) system.

Roadways as Vectors

Despite increased efforts to stop the spread of invasive plants along highway corridors, weeds continue to expand from roads into adjacent lands—farmland, forests, and ranches. Whether invasive species migrate through highway corridors naturally or via maintenance or construction practices is a subject of debate. However, mud on the tires of bulldozers or debris on the blades of mowers can easily transport seeds or vegetative parts of invasive species from one site or project to the next.

Through Small Business Innovation Research grants, FHWA supported the development of an affordable weed washer to remove soil and vegetation from the undercarriages of construction equipment and thereby diminish invasions caused by maintenance practices.

Janet Nelson, Okanogan County Noxious Weed Control Board

(L-R): Lance Skelton, Kirkes Harrison, and Les Hurlbert of Okanogan County (WA) Department of Public Works posted this first Weeds Cross Borders partnership sign, and more signs will come, both in British Columbia and Washington.

Weed washers for highway maintenance and construction use are expected to be available by late 2010.

Searching for Solutions

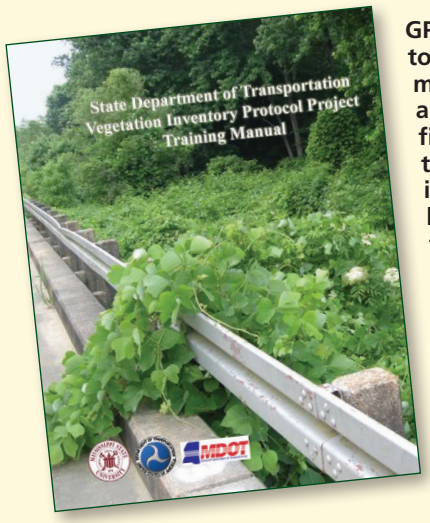
Since 1999, based on the mandate from Executive Order 13112, FHWA has encouraged State DOTs to inventory invasive plants and other vegetation along roadsides. The other plants include endangered species, native remnants, and existing plantings.

"A geographic inventory of key roadside vegetation types is essential for highway right-of-way managers as a basis for communicating and coordinating best management practices to effectively control unwanted species while preserving those that have value to highway operations and maintenance," says Raymond Willard, roadside maintenance program manager, Washington State DOT.

Comprehensive vegetation inventories can serve as benchmarks to measure performance of various management methods. What is working and what is not needs to be reevaluated annually, before deciding how to invest limited resources. At the same time, DOTs need to partner with other public lands agencies to share inventory information.

Vegetation managers need to know where the invasives are and where they are spreading, and they need to know this information *now*. One of the long-awaited tools for highway vegetation managers is an affordable GPS and protocol. With so many GPS products available on the consumer market, singling out a tool that is convenient for vegetation managers is essential—a GPS that can be mounted on a dashboard, has good display visibility, is capable of recording necessary fields of information, is cost effective, and is compatible with other data formats used by DOTs.

With GPS data incorporated into a regional GIS database, decisionmaking is likely to become more effective because the manager then will have the big picture. To address this need, FHWA funded analysis by Mississippi State University of a GPS protocol appropriate to transportation needs and compatible with common hand-held systems. Requisites for the protocol included requiring minimal training for learning to use it, meshing with early detection and rapid response capabilities,



GPS units are now affordable inventory tools used daily by vegetation management crews. Mississippi State University and Mississippi DOT developed a protocol, field-tested the tool, presented inventory training in 2009, and developed the training manual shown here. This protocol will help identify where invasive weed infestations like the pictured kudzu are located and the effectiveness of DOT treatments over time. *Photo: Mississippi State University and Mississippi DOT.*

allowing incorporation into regional GIS data, and creating the foundation for providing decisionmakers with an overview of vegetation challenges. The protocol also needed to be compatible with national standards such as the accepted North American Weed Management Association standard. The Mississippi DOT and Mississippi State University worked with FHWA to develop the training manual, now available at www.gri.msstate.edu/publications/docs/2009/09/6619DOT_Veg_Inventory_Project_Training_Manual.pdf.

A Land Ethic

"We are the road-buildingest nation on earth," former First Lady Claudia Taylor (Lady Bird) Johnson wrote in 1993. "And inevitably highways affect the lives of the people, for better or for worse. Therein lies both the glory and the burden of road building."

What follows logically is the glory and burden of *maintaining* highway corridors. Just as the transportation community is part of the problem, so it is also part of the solution, as demonstrated by the sample partnerships described earlier.

So is the war being won? In some States and regions and with some species…perhaps. At least a start is being made by adopting strategies that are expected to ultimately succeed.

In order to win, transportation vegetation managers need to reach out to all land managers and collaboratively adopt a land ethic—a commitment to environmental stewardship—or strengthen the ones they already employ. As part of this ethic, managers of highway construction and maintenance projects need best management practices to minimize impacts, especially soil disturbances. DOTs also must take advantage of innovative approaches, including those that are proven to reduce costs and environmental impacts. Perhaps most critically, all land managers and DOTs must respond quickly and effectively to new weed infestations in order to reduce long-term economic and environmental consequences.

"Protecting the utility, beauty, and intrinsic value of our roadside biota remains our responsibility. It's the only management decision that makes sense," wrote J. Baird Callicot and Gary K. Lore in an article, "Introducing a Roadside Land Ethic: It's Common Sense," in *Roadside Use of Native Plants*.

Mary Ann Rondinella is an environmental program specialist with the FHWA Resource Center Environment Technical Service Team. Prior to joining the Resource Center in 2003, she was an environmental protection specialist at the FHWA California Division. She also worked for the U.S. Department of Energy and the U.S. Army. She holds a B.S. degree in chemical engineering from Northwestern University.

Bonnie L. Harper-Lore, prior to her retirement from FHWA, was a restoration ecologist and headed FHWA's Roadside Vegetation Management Program. Harper-Lore is coauthor of *Roadside Weed Management* (FHWA-HEP-07-017) and editor of *Roadside Use of Native Plants* (FHWA-EP-99-014). She holds an M.S. degree from the University of Wisconsin–Madison.

For more information, contact Mary Ann Rondinella at 720-963-3207 or maryann.rondinella@dot.gov.

Complete STREETS

by Robin Smith, Sharlene Reed, and Shana Baker

From policy statements to programs and planning, opportunities abound for improving the accessibility of the transportation system for all users.

For decades, the purpose and goal of street design in the United States was to move as much motorized traffic as expeditiously as possible from point A to point B, regardless of whether the traffic was moving along a major freeway or commercial arterial, or through a city center, village main street, or even a residential neighborhood. Applied speed limits and street design standards would vary from route to route, but in general street design and traffic engineering were all about moving cars and trucks from their origins to their destinations. Even as early as the beginning of the 20th century, officials in New York City mandated the narrowing of sidewalks to create more numerous and wider lanes to accommodate motorized traffic. Pedestrians, planners thought, did not need much room to maneuver.

However, developing a transportation system primarily for motorized vehicular traffic has failed to meet the travel needs and preferences of large segments of the country's population. Among the many factors influencing the planning, design, and operation of today's streets are concerns about accommodating the needs of an aging population, improving public health and fitness, reducing dependence upon foreign oil, minimizing transportation costs, creating and maintaining vibrant neighborhoods, reducing the fossil fuel emissions that contribute to climate change, and adopting greener and more sustainable lifestyles. Ensuring that roads provide safe mobility for all travelers, not just motor vehicles, is at the heart of a new approach to envisioning and building surface transportation facilities known as "complete streets."

According to the National Complete Streets Coalition, established in 2005, complete streets are those designed and operated to enable safe access and travel for all users. Pedestrians, bicyclists, motorists, transit users, and travelers of all ages and abilities will be able to move along the street network safely.

"Complete streets policies help communities make a clear commitment to planning all future transportation projects to provide for the safe travel of everyone using the road," says Barbara McCann, director of the National Complete Streets Coalition. "Once that commitment is made, planners and engineers have a clear direction to develop new processes, design manuals, and on-the-ground solutions that welcome everyone."

Although the Federal Highway Administration (FHWA) does not have an official complete streets policy, the concept is closely associated with the principles promoted by the Interagency Partnership for Sustainable Communities, a joint endeavor involving the U.S. Department of Transportation (USDOT), U.S. Department of Housing and Urban Development (HUD), and U.S. Environmental Protection Agency (EPA). The partnership aims to

This intersection in Charlotte, NC, safely accommodates all road users, including motorists, transit riders, bicyclists, and pedestrians. *Photo: Charlotte Department of Transportation.*

provide more transportation choices; support existing communities through transit-oriented, mixed-use development and land recycling (that is, reuse of abandoned, vacant, or underused properties for redevelopment); and value communities by investing in healthy, safe, and walkable neighborhoods.

As stated by Transportation Secretary Ray LaHood, "President Obama has challenged us to transform the way transportation serves the American people by creating more choices and encouraging less carbon-intensive transportation, and we are working hard on that challenge…It turns out that a complete streets approach offers the perfect intersection of my twin guideposts: safety and livable communities."

In the first of a two-part series on street design, this article looks at how complete streets policies can help make the transportation system more accessible to all travelers. An upcoming article will focus on concepts and practices for designing streets to be more environmentally responsive and sustainable. Combining these two perspectives using a multidisciplinary approach will help maximize the effectiveness and sustainability of the Nation's transportation network.

Defining Complete Streets

Although the guiding principle for complete streets is to create roadways and related infrastructure that provide safe travel for all users, each complete street has to be customized to the characteristics of the area the street serves. A complete street also has to accommodate the needs and expectations of the travelers who want to access or pass through the surrounding neighborhood, community, or region.

According to the National Complete Streets Coalition, typical elements that make up a complete street include sidewalks, bicycle lanes (or wide, paved shoulders), shared-use paths, designated bus lanes, safe and accessible transit stops, and frequent and safe crossings for pedestrians, including median islands, accessible pedestrian signals, and curb extensions. Certainly, a design for a complete street in a rural area will look quite different from one in an urban or suburban area. For example, a complete street in a rural area could involve providing wide shoulders or a separate multiuse path instead of sidewalks. The common denominator, however, is balancing safety and convenience for everyone using the road.

Transit, including bus and fixed-rail services, can become a more attractive option when access points that comply with the requirements of the Americans with Disabilities Act are integrated into roads, sidewalks, and parking areas to allow easier, safer access for all users.

In addition to the new USDOT-HUD-EPA partnership, many other programs at the Federal, State, metropolitan, and local levels already embrace the complete streets approach—or provide the framework to do so—and can help foster more livable communities. Below are a few examples.

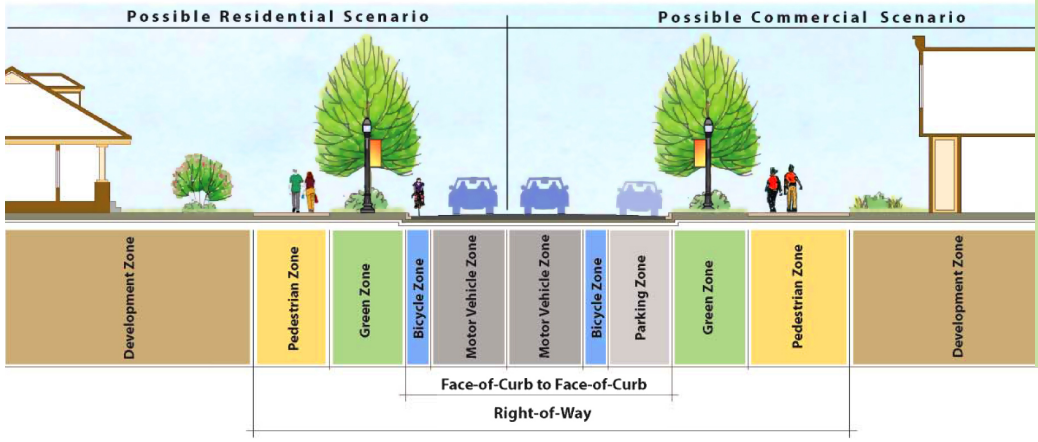
United States Code

Several Federal laws and FHWA regulations pertaining to transportation planning and project development support the concept of complete streets. A current Federal statute, United States Code, Title 23, Chapter 2, Section 217 (23 USC 217), mandates that "bicycle transportation facilities and pedestrian walkways shall be considered, where appropriate, in conjunction with all new construction and reconstruction of transportation facilities, except where bicycle and pedestrian use are not permitted." To elaborate on that requirement, FHWA developed bicycle and pedestrian guidance (available at www.fhwa.dot.gov/environment/bikeped/bp-guid.htm) that further explains how and when FHWA requires or encourages accommodation of pedestrians and bicyclists in Federal-aid highway projects.

On March 15, 2010, Secretary LaHood announced the release of an updated "Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations." The policy statement reemphasizes USDOT's support for the development of fully integrated transportation networks and encourages States, local governments, and other organizations to adopt similar policy statements and commit to

This construction project in a rural area will widen the shoulder to accommodate nonmotorized traffic.

www.pedbikeimages.org, Austin Brown



A complete street anticipates and accommodates the needs of all road users, as indicated in this diagram from Charlotte, NC's *Urban Street Design Guidelines* for the design of a proposed residential or commercial avenue. *Source: City of Charlotte.*

accommodating bicyclists and pedestrians in the transportation system. The policy statement also calls on transportation agencies and communities to go beyond minimum design standards and requirements to create safe, attractive, sustainable, accessible, and convenient bicycling and walking networks, and offers recommendations on how to do so.

The design and construction of bicycle and pedestrian facilities are eligible to receive funding through core Federal highway funding categories, such as the Surface Transportation Program, the National Highway System, and the Highway Bridge Program.

Safe Routes to School

Another example, the Federal Safe Routes to School program, brings together individual schools and school districts, students, parents, and law enforcement to develop programs to encourage students from kindergarten through 8th grade to walk or bike to and from their schools. Not only does the program promote exercise in students' daily lives, it also reduces the need for parents to drive their children and the resulting traffic congestion on streets around schools in the mornings and afternoons. FHWA provides Federal funds to all States to distribute to eligible recipients, usually through a competitive grant process, to support educational, safety, and other programs and to pay for infrastructure improvements. To ensure the program's success, FHWA requires each State to designate a full-time Safe Routes to School coordinator. (For more information, see "Safe Routes to School—Making a Big Difference Via Small Steps" in the July/August 2009 issue of PUBLIC ROADS.)

To take only a single example out of many, school officials at Murch Elementary School in Washington, DC, engaged community partners in a Safe Routes to School program and, in a single school year, made a number of improvements to help ensure a safer walking and bicycling environment. Specifically, the program reversed a school policy prohibiting students from bicycling to school without special permission. The school also secured neighborhood support for construction of new sidewalks, reduced barriers to walking in surrounding neighborhoods, and implemented a 17-member student safety patrol program to enforce safe driving and parking behaviors around the school.

According to Robin Schepper, a parent volunteer at Murch Elementary, getting support from children and their parents, as well as expanding into the community, is critical to creating an environment and infrastructure that makes it safer for young people to walk and bicycle to school. Also, she says, "we reached out to senior centers in our neighborhood because they face the same barriers as students do walking in our neighborhood—speeding traffic, pedestrian lights that change too quickly, and the lack of traffic lights on high-volume streets."

In October 2009, U.S. Congressman James L. Oberstar, chairman of the House Transportation and Infrastructure Committee, recognized the school with the 2009 James L. Oberstar Safe Routes to School Award for outstanding achievement. The award acknowledges the school's success in building partnerships within the school and with the surrounding community and the District Department of Transportation (DDOT).

Context Sensitive Solutions

Another FHWA-backed approach is applying context sensitive solutions (CSS) to help ensure that streets are indeed "complete" in the sense of being appropriate for the area in which a project is implemented. As defined by FHWA and the American Association of State Highway and Transportation Officials, CSS is a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting. CSS leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, and infrastructure conditions.

Transportation officials can apply CSS early in the planning process and throughout project development and delivery. Some of the major elements of CSS include the following:

- Early and frequent consultation and collaboration with stakeholders and the community during planning and design, and using communications tools, such as design visualization, that help citizens better understand project proposals.
- Use of an interdisciplinary team to oversee and manage project development.
- Emphasis on enhancing and retaining the sense of place or uniqueness of an area and its valued resources and features.
- Consideration of multiple alternatives with the goal of building consensus on a final project, which might include elements of the various alternatives.
- Minimization of disruptive impacts on the community.

Jennifer Hefferan, DDOT

As part of the Safe Routes to School program, DDOT constructed segments of new sidewalk, such as this one, near Murch Elementary in Washington, DC.

For example, the small community of Bingen, WA, and the Washington State Department of Transportation collaborated to apply a context sensitive solution to improve SR–14 through downtown Bingen. Located along the Columbia River in southern Washington State, Bingen is home to about 680 residents. One of the town's goals was to revitalize its main street while reducing traffic congestion and improving safety along that section of SR–14. Through community outreach, the town enlisted support from residents and other stakeholders to improve the accessibility and appeal of the revamped facility.

Completed in 2004, the project incorporates wider-than-standard sidewalks with bulbouts and other streetscape improvements such as trees and street furniture to attract more people to stop and stroll through the downtown. The designers added features such as left-turn lanes and right-turn pockets to facilitate traffic movement through town and to address the broader safety and congestion concerns. By combining transportation funds with economic revitalization grants, the project sponsors were able to improve the corridor for motorists, pedestrians, and other users.

"At first, some businesses and community residents were skeptical about the street improvements, especially proposals to spend a sizeable sum on sidewalks and trees," says Bingen City Administrator Jan Brending. "But once the project was completed, they were amazed at the difference it made. Downtown Bingen is now much more pedestrian friendly and livable, which has attracted businesses and revitalized the area."

The Role of State DOTs

Under Federal statute 23 USC 217, State DOTs are required to use a portion of certain Federal funds to hire a State bicycle and pedestrian coordinator. This position is responsible "for promoting and facilitating the increased use of nonmotorized modes of transportation." In addition, in accordance with the *Code of Federal Regulations* (23 CFR 450.214), each State DOT, in cooperation with metropolitan planning organizations (MPOs), is required to develop a multimodal plan that includes nonmotorized and public transportation.

The roles of DOTs and other State agencies in supporting transit programs vary significantly among the States. State laws, programs, institutional arrangements, and other factors influence how a State defines and meets it obligations. Regardless, State DOTs can work with transit operators to help ensure that, through road design standards, transit users can access transit services safely and conveniently along State-maintained routes in urban and rural areas.

Several States have adopted complete streets practices through a variety of mechanisms, including policy statements and revisions to project development and design guidelines. For example, in 2001, the California Department of Transportation (Caltrans) issued a director's policy on context sensitive solutions that describes the responsibilities of key officials and their respective offices or divisions to define and apply CSS throughout all aspects of transportation planning and project development, design, and implementation. As part of that effort, Caltrans also issued a deputy directive titled "Complete Streets—Integrating the Transportation System," which defines a complete street as a "transportation facility that is planned, designed, operated, and maintained to provide safe mobility for all users, including bicyclists, pedestrians, transit riders, and motorists appropriate to the function and context of the facility." The directive states that Caltrans will facilitate creation of complete streets, "beginning early in system planning and continuing through project delivery and maintenance and operations."

On the other side of the country, Massachusetts significantly revised its guidebook for street and highway design standards to allow greater flexibility and to foster a broader view of the role street and highway design plays in maintaining and enhancing community values and amenities. In fact, multimodal consideration is one of three guiding principles in the updated guidebook: *Massachusetts Highway Department: Project Development and Design Guide*. Specifically, the guide states that the multimodal focus is "to ensure that the safety and mobility of all users of the transportation system (pedestrians, bicyclists, and drivers) are considered equally through all

Where SR–14 passes through the town of Bingen, the Washington State DOT worked with local officials to improve accessibility and enhance the appeal of the revamped facility in the downtown area. Improvements included wider sidewalks and these landscaped bulbouts planted with trees and flowers.

Kenneth Hash, Washington State DOT

The effect of applying Charlotte's *Urban Street Design Guidelines* is apparent on Elizabeth Avenue, shown here, where pedestrians, cars, and buses coexist, and landscaping creates an aesthetically pleasing environment.

EPA/Abby Hall

phases of a project so that even the most vulnerable (for example, children and the elderly) can feel and be safe within the public right of way."

The Role of MPOs

In metropolitan areas with populations greater than 50,000, the responsibility for transportation planning lies with designated MPOs. Given their local and municipal focus, MPOs hold the greatest responsibility for adopting livability goals and promoting concepts such as complete streets in an urban region. The metropolitan planning process requires the development of integrated, multimodal transportation plans that address not only roadways, but also transit services and facilities, intermodal connections, pedestrian walkways, bicycle facilities, and other supportive programs and activities.

Transportation planning by MPOs can foster implementation of complete streets principles through various activities:

- Developing land use, economic development, and transportation (or other infrastructure) plans in a coordinated manner, with all elements supporting a common vision.
- Facilitating alternative transportation modes through land use goals and design standards.
- Connecting transportation projects and programs to public and private investments so they complement each other and support broader community goals.
- Accommodating the flow of freight while avoiding or minimizing negative impacts on residential areas, city centers, and other users of the transportation system.
- Considering a range of strategies, tools, and modal options to support complete streets and similar livability goals and activities.

Although not all facilities within a metropolitan region are significant enough to include in a metropolitan transportation plan or receive Federal funding through that plan, an MPO can ensure that member local governments, the relevant State DOT, and transit agencies consider the needs of all residents and visitors in that region. For example, an MPO can set appropriate regional goals and funding priorities, ensuring that a robust public involvement process includes key stakeholders, interest groups, and the public. The MPO also can coordinate regional planning with local transportation and comprehensive plans to include not only roadways but also facilities and systems related to transit and nonmotorized traffic.

For example, the Cheyenne MPO in Wyoming has taken an active role in implementing elements of its award-winning, integrated city-county comprehensive transportation plan known as PlanCheyenne. With the MPO's assistance, the Cheyenne Planning Department is putting the plan recommendations into law. Cheyenne had three separate code documents covering subdivisions, zoning, and street and site design standards, which were not necessarily compatible with each other. Now, however, the city is adopting a unified development code that will reflect the complete streets ideas presented in PlanCheyenne. The intent is to develop a balanced design for regional and local routes that safely accommodates all potential users of the streets and rights-of-way. In addition, the city expects to limit block sizes to enhance neighborhood connectivity and circulation for all modes. The Cheyenne MPO also approaches all corridor planning activities with the intention of creating complete streets.

Although street design standards usually are the purview of the State DOT and local governments, an MPO can assist those agencies through education and technical assistance to incorporate design elements that accommodate all users. An MPO can take a leadership role to establish regional policies that encourage complete streets design through a variety of programs and processes, and give funding preference to projects that reflect complete streets principles. Each MPO needs to decide if and how it will promote complete streets within its region, but its approaches can be creative and tailored to local circumstances.

As another example, in January 2009, the Bloomington/Monroe County MPO in Indiana took the lead in its region when it adopted a complete streets policy that applies to all local roadway projects where the MPO has programming authority to allocate Federal funding. The

initial impetus behind the complete streets policy came from the MPO's citizens advisory committee. From there, the MPO facilitated regional collaboration and consensus building among key transportation stakeholders to craft a regional policy. "It was a challenging process to develop the policy, but we believe it was worth the effort," says Josh Desmond, director of the Bloomington/Monroe County MPO. "The policy will foster consideration of the needs of all road users in transportation plan and project development. No user will be left behind."

Local Governments and Transit Operators

In many cases, local governments are the organizations that ultimately decide how to implement a complete streets policy or ordinance within their respective jurisdictions, particularly on facilities owned and operated by those local entities. According to the National Complete Streets Coalition, by early 2010, 124 jurisdictions had adopted or committed to adopt complete streets policies. In addition, either with the State DOT or in concert with other members of the regional MPO, local governments can support efforts to apply complete streets concepts across jurisdictional boundaries and to all roads within their respective jurisdictions, regardless of which government agency "owns" them.

The city of Charlotte, NC, is one example of a local government that has implemented a complete streets policy. In October 2007, Charlotte's city council adopted its *Urban Street Design Guidelines* to help the city shape its development patterns and provide residents and visitors with viable choices for how they move about the city. The guidelines include recommending block lengths for new developments that foster a denser, well-connected network of streets that in turn promotes more compact building design. The city also encourages wide planting strips to allow large, mature trees to continue growing, enhancing Charlotte's tree canopy and making the streets more pleasant for pedestrians and motorists alike. In addition, Charlotte is making pedestrian crossings more visible and changed traffic signal timing to better accommodate pedestrians. In recognition of these successes, EPA awarded Charlotte the 2009 National Award for Smart Growth Achievement in Policies and Regulations.

Transit operators too can encourage or require transportation plans and project design elements to accommodate all riders, including pedestrians, bicyclists, and disabled individuals who use transit as part of their travels. Through institutional and working relationships with government agencies and the private sector, transit providers have a say in or bear responsibility for developing and designing transit stops, stations, and transfer/intermodal centers. Close coordination with local governments, MPOs, State DOTs, and even private developers who have ownership of streets and other properties adjacent to transit access points can help ensure that riders have convenient and safe access to transit services.

For example, in 2004 the Alameda–Contra Costa Transit District (AC Transit) in California published *Designing With Transit: Making Transit Integral to East Bay Communities*, a guidebook targeting elected officials, local staff, and community builders. The document serves as a toolbox for community agencies working to make their main streets more vital and pedestrian friendly, and aims to help integrate transit more effectively into the local and regional planning processes. According to Nathan Landau, a senior transportation planner with AC Transit who helped develop the manual, Alameda has retrofitted a major arterial with streetscape improvements and customized bus stops consistent with the principles and goals of *Designing With Transit*. At least one member jurisdiction is considering incorporating portions of the manual into its comprehensive plan. In the next update to the guidebook, Landau adds, "complete streets principles will be clearly referenced, now that member jurisdictions are more familiar with the term."

Thinking Beyond the Car

Transportation agencies and their partners already have the ability—through legislation, Federal programs, policy statements, design guidelines, and planning—to provide more complete streets to all travelers by taking advantage of the many opportunities to go beyond traditional approaches.

As Secretary LaHood said in a recent posting on "Fast Lane," the Secretary's official blog, "We need roadways designed to account for the needs of everyone who uses them, whether driving, walking, or riding in a wheelchair or on a bicycle."

All transportation professionals, regardless of their respective disciplines, have the power to help create a transportation network that rises to the challenge of meeting the mobility requirements of the 21st century. Getting there requires a shift in mindset from designing an auto-focused highway system to operating a transportation network that accommodates all users and modes safely and conveniently.

Robin Smith is a senior transportation planner in the FHWA Office of Planning. In her 30 years with FHWA, Smith has worked primarily as a transportation planner in FHWA division, region, and headquarters offices. She received her B.S. from Michigan State University and her master's of regional planning from the University of Michigan.

Sharlene Reed is a community planner with FHWA, working in the newly formed Office of Human Environment, Livability Team. Previously, she was a neighborhood transportation planner with DDOT. Reed is a graduate of the University of the District of Columbia with a B.A. in political science and a master's of urban and regional planning.

Shana V. Baker is a community planner with FHWA's newly formed Office of Human Environment, Livability Team. She has a B.A. in political science and an M.A. in urban planning from the University of Akron.

For more information, visit www.fhwa.dot.gov/context/what.cfm or www.completestreets.org. Or contact Robin Smith at 720-963-3072, robin.smith@dot.gov; Sharlene Reed at 202-366-9629, sharlene.reed@dot.gov; or Shana Baker at 202-366-4649, shana.baker@dot.gov.

IntelliDrive℠

Safer.
Smarter.
Greener.

USDOT introduces a new strategic plan for multimodal ITS research that aims to produce safer, interconnected, and more convenient travel.

by Shelley J. Row

Imagine a world where automobiles and other vehicles can talk to each other in order to avoid or at least reduce the number and severity of crashes, where vehicles can communicate with traffic signals to eliminate unnecessary stops, where travelers can obtain the latest information about travel times on various modes and route options, and where transportation managers have the data to assess accurately the performance of the multimodal transportation system.

Connectivity is the key to transforming this imagined world into a real one: connectivity with and between vehicles, between vehicles and roadway infrastructure, and among vehicles, infrastructure, and passengers' wireless devices.

These kinds of connectivity will not become available without research that is guided by a well-disciplined approach and that investigates key questions related to applications, technology, and policy. On behalf of the U.S. Department of Transportation (USDOT), the Research and Innovative Technology Administration (RITA) recently released *Intelligent Transportation Systems (ITS) Strategic Research Plan, 2010–2014* (FHWA-JPO-10-028), which outlines such an approach.

At the 2009 annual meeting of the Intelligent Transportation Society of America, U.S. Transportation Secretary Ray H. LaHood said, "We believe that cutting-edge ITS technologies are the key to improving highway and vehicle safety, reducing traffic congestion and

(Above) IntelliDrive safety applications would use wireless vehicle-to-vehicle communications, represented here by circles around each vehicle traveling on this multilane highway, to improve safety by informing drivers of hazards they might not see. *Photo: www.shutterstock.com, Mikhail Tchkheidze.*

CO_2 [carbon dioxide] emissions, and creating a more energy-efficient, sustainable, and performance-based transportation system."

IntelliDrive

The core of the *ITS Strategic Research Plan* is IntelliDrive℠, a USDOT initiative to create interoperable connectivity among vehicles, infrastructure, and passengers' wireless devices to produce safety, mobility, and environmental benefits. The plan focuses on key research questions related to IntelliDrive applications, technology, and policy. Research results will provide the information needed to make key decisions regarding strategies for implementing IntelliDrive.

In 2003, staff with USDOT's ITS program and others recognized that the interaction between vehicles (vehicle-to-vehicle or V2V) and between vehicles and the roadway (vehicle-to-infrastructure or V2I) holds the potential to address safety issues and other difficult transportation challenges. Building from earlier ITS research (the Intelligent Vehicle Initiative—IVI), USDOT launched the Vehicle Infrastructure Integration (VII) program in 2003.

As the VII program progressed from the research stage into commercial testing and marketing, the researchers recognized that the scope of the ITS program needed to be expanded to explore potential applications of the newer wireless and computing technologies. To better reflect the expanded research, in 2009 USDOT rebranded the VII program as IntelliDrive.

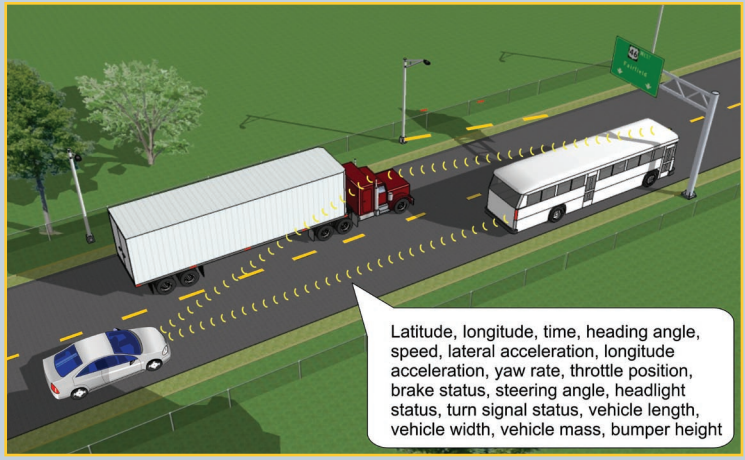
In addition, two other research initiatives—USDOT's Cooperative Intersection Collision Avoidance Systems (CICAS) and SafeTrip-21—continue as part of IntelliDrive today. Researchers with the CICAS program develop and test technology and applications to reduce crashes at signalized and stop-controlled intersections, including technology to enable vehicles to communicate with traffic signals to facilitate in-vehicle warnings to drivers if they are about to run a red light. At stop-controlled intersections, various technologies are being tested to give drivers who have made a legal stop information about adequate gaps in cross street traffic streams for making a movement. SafeTrip-21 is a research initiative to adapt and test a suite of technologies available today to achieve safety and mobility enhancements in the near term. The applications include collecting fleet-based probe data from a multi-State region, using portable devices to gather traffic flow data, and providing travelers with real-time data that compare travel times on various routes and transit options.

Real-World Tests

Under these various programs, USDOT conducted a number of real-world tests. For example, the CICAS initiative conducted a pilot test of an intersection violation warning prototype in Blacksburg, VA. In the 2007–2008 test, 87 drivers navigated a predetermined route on public roads. The route included 13 intersections with roadside communications equipment: three intersections controlled by traffic signals and 10 controlled by stop signs. The pilot test showed that the prototype was ready for larger scale field testing. The CICAS initiative has been folded into the IntelliDrive program, and any further testing will be part of the broader initiative.

In 2008 and 2009, USDOT and its partners conducted a VII proof-of-concept test at specially designed test beds located in Oakland County, MI, and Palo Alto, CA. The researchers conducted these basic tests to assess the communication capabilities and characteristics of dedicated short-range communications radios on a 5.9 gigahertz band dedicated by the Federal Communications Commission for transportation safety purposes and designed for short-range communication among vehicles traveling at high speeds. The tests indicated that the VII concept is feasible and uncovered additional research, technical, and policy issues that the IntelliDrive program is designed to address. Questions that need additional research and testing include whether network designs using dedicated short-range communications technology will function in a full-scale operational environment and are secure and adequately protective of user privacy.

In addition to addressing the remaining questions, USDOT and



RITA/USDOT

V2V communication among vehicles is illustrated in this drawing of a truck, bus, and car, along with the types of data shared, as the vehicles travel on an interstate.

Dan Morin, Volpe Center/USDOT

This illustration shows a vehicle broadcasting "Here I Am" messages as part of basic V2V communications.

Dan Morin, Volpe Center/USDOT

This illustration depicts a traffic signal and a vehicle sharing information about signal phase and timing as part of V2I communications. As the driver approaches the intersection, the traffic signal communicates a "Stop Ahead" message to the vehicle's onboard system, alerting the driver.

its partners plan to maintain the Michigan VII test bed (now the IntelliDrive test bed) for public and private sector multimodal testing of new technologies and applications.

Research Goals: Safety, Mobility, and Environmental Protection

More than 5.8 million crashes occur every year on U.S. roadways, resulting in more than 34,000 deaths annually. IntelliDrive safety applications are designed to increase situational awareness and reduce or eliminate crashes through V2V and V2I data transmission that supports driver advisories and warnings, plus vehicle and infrastructure controls. For example, IntelliDrive will expand research on V2V applications that alert a driver who is trying to change lanes if there is a car in the blind spot. Although the driver cannot see the car in either mirror due to the blind spot, these systems detect the presence of the other vehicle and warn the driver.

An example of a V2I application is an intersection violation warning application, which warns a driver who is about to enter an intersection in violation of a traffic signal. Software in the vehicle analyzes data transmitted from the vehicle and from infrastructure equipment to determine whether the driver is at imminent risk of failing to stop. If this is the case, then the traffic signal green or yellow phase could be extended to allow safe passage.

With regard to mobility applications, traffic congestion is an $87.2 billion annual drain on the U.S. economy, with motorists spending 4.2 billion hours per year sitting in traffic, according to the *2009 Urban Mobility Report* published by the Texas Transportation Institute. Still in the early stages of development, IntelliDrive mobility applications could combine data from a variety of wireless sources, including vehicle onboard equipment that transmits location, speed, and other operating data; infrastructure-based equipment that transmits the status of traffic control devices; and mobile devices carried by passengers that transmit anonymous location data.

Combining this information with data currently being collected by public sector agencies through loop detectors, traffic cameras, and ramp meters would provide system managers and users with detailed, real-time, dynamic data about the status of the transportation system and the vehicles using it. Transportation managers could use this information to manage the system for optimal performance. They also could deliver the data to users to help them make more efficient or convenient travel choices. For example, real-time data about the location of all vehicles on a highway system would enable traffic managers to optimize signals to facilitate flow on a temporary detour established to route traffic away from an incident. IntelliDrive also will provide mile-by-mile, block-by-block awareness of weather and road conditions, enabling transportation managers and travelers to make safer, more efficient decisions in adverse conditions.

In terms of environmental issues, tailpipe emissions are the single largest human-made source of CO_2, nitrous oxide (N_2O), and methane. Stop-and-go traffic results in 2.8 billion gallons of fuel wasted every year, according to the *2009 Urban Mobility Report.* Providing motorists with real-time information about traffic congestion and other travel conditions could help them make more informed decisions that could reduce the environmental impacts of their trips.

Fuel saved due to improvements in traffic flow avoids carbon emissions and several other categories of pollutants. Informed travelers might decide to avoid congested routes, take alternate routes, use public transit, or reschedule their trips. The bottom line benefits of technologies that help reduce fuel consumption are cleaner air and water.

Development, Funding, and Programs

USDOT developed the research plan through a process that involved external and internal stakeholders. In spring 2009, the Department sought input from the ITS community through a request for information and an open public meeting. Using that stakeholder input, multimodal teams from within USDOT developed various aspects of the plan.

The *ITS Strategic Research Plan* assumes that USDOT's ITS research program will receive the same level of funding as in previous years: $100 million per year for 5 years. In 2010, up to $77 million will be dedicated to ITS research, $49 million of which will be devoted to wireless connectivity. All research activities include "Go/No-Go" decision points at major milestones. At those points, USDOT will assess the expected costs and benefits of additional elements of the research.

The *ITS Strategic Research Plan* has four main program components: IntelliDrive research, mode-specific

research, exploratory research, and crosscutting support.

IntelliDrive Research Areas

For IntelliDrive to be implemented in the real world, research must explore and validate the effectiveness of potential applications. Included, as part of the IntelliDrive program, is research on human factors to examine how to use technology to increase safety without creating driver distraction. This research will test the most effective way to deliver information to drivers without creating unintended consequences. IntelliDrive research on applications will include V2V and V2I communications technology, real-time data capture and management, dynamic mobility applications, road weather management, and real-time information synthesis.

V2V and V2I communications technology based on dedicated short-range communications are designed to increase motorists' awareness and reduce the number of crashes by warning them of dangerous driving situations. Research on V2V is designed to determine the safety and effectiveness of V2V applications so that the National Highway Traffic Safety Administration (NHTSA) can decide whether to pursue a rulemaking process to require or encourage this technology on some or all vehicles. For V2I safety research, an initial focus will be applications that communicate traffic signal phase and timing information to vehicles. All of the V2V and V2I research will examine the potential use of aftermarket devices to expedite invehicle capabilities, plus the amount and type of infrastructure needed to support the applications.

Real-time data capture and management research will create and expand access to high-quality multimodal transportation data captured from connected vehicles, mobile devices, and infrastructure.

Dynamic mobility applications research will identify transformative applications and innovative methods to manage and operate transportation systems based on the availability of new data sources and communications methods. The goal is to develop applications that can provide travelers and system operators with greater access to real-time information about the transportation system to facilitate improved decisionmaking.

Road weather management research will consider how travelers and transportation agencies can use vehicle-based data on current weather and road conditions to make decisions that take into account those conditions and forecasts. This data can supplement data from existing road weather information systems and can be used to better manage winter maintenance activities and enhance weather-related traveler information.

Applications for the Environment: Real-Time Information Synthesis (AERIS) research focuses on the capture, synthesis, and delivery of real-time, vehicle- and infrastructure-based, environmentally relevant information to support system management that advances environmental improvements within the transportation system, including protection of air and water quality. Still in the early stages of development, the AERIS research program is intended to generate, capture, and analyze data to create actionable information that allows system users and operators to make green transportation choices, such as which travel modes and routes offer the most environmentally friendly path to a destination and how to operate traffic signals and other system elements to reduce vehicle emissions.

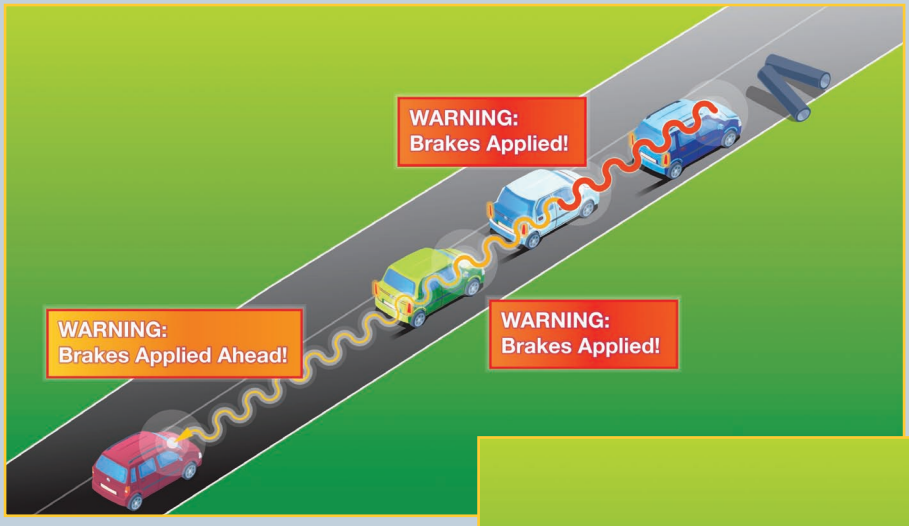
Mode-Specific and Exploratory Research

Mode-specific research includes active traffic management, international border crossings, roadside infrastructure for commercial vehicle operations, expansion of the Commercial Vehicle Information Systems and Networks program, multimodal integrated fare payment systems, and maritime applications.

Exploratory research consists of a rail exploratory initiative, which will investigate the application of IntelliDrive technologies within the rail environment, and an exploratory research solicitation through which USDOT will work with the research community to identify other promising technologies and applications.

(Bottom) Shown here is the intersection test site in Oakland County, MI, used in the proof-of-concept test of 5.9 gigahertz dedicated short-range communications technology. (Right) A closeup of the prototype equipment used in the test.

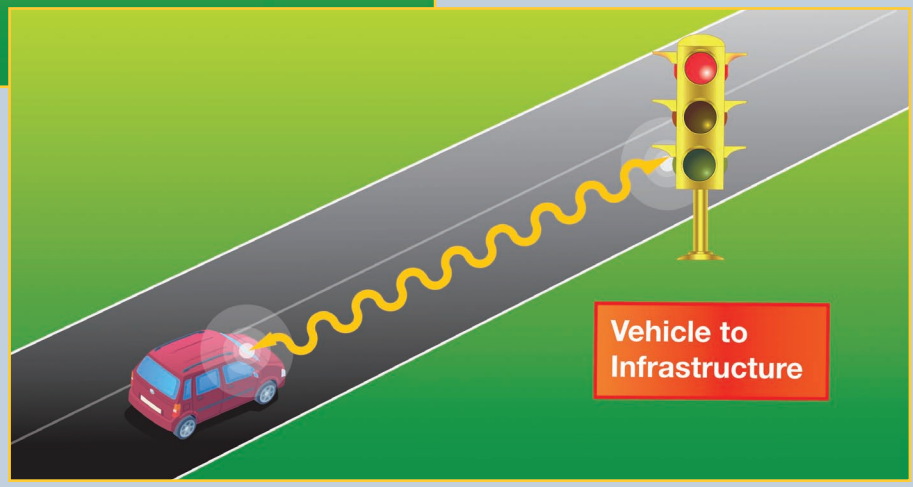
Photos: Vehicle Infrastructure Integration Consortium



Philip Thornton, Volpe Center/USDOT

(Left) IntelliDrive safety applications have the potential to reduce crashes through advisories and warnings during imminent crash situations, such as when a vehicle ahead stops suddenly due to a road obstruction, as shown in this illustration.

(Below) Through IntelliDrive applications, vehicles could "talk" to traffic signals, as depicted in this drawing, to eliminate unnecessary stops and help drivers operate vehicles for optimal fuel efficiency.



Philip Thornton, Volpe Center/USDOT

Crosscutting Support And Next Steps

The plan also includes crosscutting activities that will serve as a foundation for implementation of the research results. Among the crosscutting activities is research on nontechnical questions needed to establish the basis for wide-scale deployment, such as defining deployment scenarios, determining financing and governance options, and identifying means of addressing liability, privacy, data ownership, and other institutional issues.

Also needed are the harmonization of standards and a common system architecture, as well as certification processes for the most critical safety technologies. International cooperation and coordination are important aspects of the new strategic plan. In a recently signed joint declaration of intent, USDOT and the European Union agreed to work together on common elements of the research, including selected applications, harmonization of international ITS standards, and shared testing tools and methodologies.

The objective is to work with the international standards community to increase vehicle connectivity. Harmonization facilitates interoperability among products and systems, which benefits transportation management agencies, vehicle manufacturers, equipment vendors, and other stakeholders. Overcoming institutional and financial barriers to technology harmonization could enable stakeholders to realize lower life-cycle costs for the acquisition and maintenance of systems.

Next steps relate to research on applications of new technologies and validation of the benefits of those technologies, determination of the minimum infrastructure needed to be functional, and research on the degree of market penetration required for the system to have the desired effect. Technical questions concern the stability, reliability, security, and interoperability of the new technologies, and the availability of international standards to ensure interoperability. Policy questions involve the policies, governance, and funding required to ensure sustainability and privacy, while avoiding driver distraction.

Although the strategic plan, which was released in December 2009, establishes an overall vision and broad areas of research, it does not define the details of how the research will be executed. USDOT is developing a more detailed plan in coordination with various internal and external stakeholder groups, and will release that plan in summer 2010.

"Developed with strong stakeholder input, the *ITS Strategic Research Plan* outlines a vision for a national, multimodal surface transportation system that will lead to unprecedented safety, mobility, and environmental sustainability, while sparking countless other commercial applications of ITS technologies," says RITA Administrator Peter Appel.

Shelley J. Row has been director of USDOT's ITS Joint Program Office since 2007. Previously, Row worked in FHWA's division offices in Arizona, California, and North Carolina. She also served as engineering systems manager in the Georgia Division Office, where she was responsible for ITS project implementation in preparation for the 1996 Olympic Games. In 2000, Row became director of FHWA's Office of Transportation Operations. She holds bachelor's degrees in civil engineering and architecture from Texas Tech University and an MBA in management from Virginia Tech.

For more information about the ITS Strategic Research Plan*, visit www.its.dot.gov/strat_plan or contact Mike Pina at 202-366-3700 or mike.pina@dot.gov.*

From Hot to Warm

by Matthew Corrigan, Dave Newcomb, and Thomas Bennert

FHWA and its partners continue to advance warm-mix asphalt, which can cut production costs and emissions and still provide long-lasting pavements.

(Above) A contractor's paving crew is applying a layer of warm-mix asphalt on State Route 2012 near Spring Mills, PA.

Production and placement of hot-mix asphalt (HMA) pavements in the United States has evolved over the last 130 years, from hand mixing and application with rakes and shovels to computerized facilities feeding highly automated remixing, placement, and compaction equipment. During this time, engineers have learned that temperature control is crucial to aggregate coating, mixture stability during production and transport, ease of placement, compaction, density, and ultimately a pavement's long-term performance. During construction, the temperature must be high enough to ensure the coating and workability of the mix, but low enough that asphalt binder draindown (when the liquid binder flows down through the mixture and pools at the bottom), aging, and hardening do not occur.

Modern performance requirements often dictate use of polymer-modified asphalt binders, strong angular aggregate, and greater in-place density of the HMA. Engineers typically use polymer modification as insurance against permanent deformation of

a pavement at high surface temperatures on high-volume roads. But mixes made with polymer binders can be more difficult to work with than mixes with unmodified binders.

For higher-traffic-volume pavements and surface courses in medium-traffic-volume pavements, specifications often mandate greater aggregate angularity. Such aggregate increases the internal friction of the material and makes it more durable, but greater angularity also increases the force required to mix and place the aggregate, especially in coarse gradations. Engineers often respond to this stiffness or lack of workability by raising temperatures for production, placement, and compaction temperatures to reduce the viscosity of the binder and improve the mixture flow.

Density specifications also affect the workability of HMA. Engineers use density as a measure of pavement quality: The greater a pavement's density, the lower its permeability to air and water and the better its long-term performance. If a mixture shows resistance to compression during compaction and therefore requires more effort to achieve the specified density, engineers typically respond by raising its temperature.

However, increasing production temperature is often expedient but not necessarily the most effective solution. The simple act of increasing the temperature can overheat the mixture and lead to accelerated aging in the short term and, ultimately, affect performance in the longer term. The adjustment also can result in greater fuel consumption, emissions, and odors at both the production plant and the paving site.

This researcher is taking a digital thermometer reading in front of the paver screed to verify the temperature of the mixture.

The Federal Highway Administration (FHWA), in cooperation with the HMA industry, researchers, and academia, is continually exploring technological improvements that will enhance the performance, construction efficiency, resource conservation, and environmental stewardship of asphalt mixtures. One approach to achieving all these goals is to reduce HMA production temperatures—sometimes by as much as 100 °Fahrenheit, °F (38 °Celsius, °C)—and to this end engineers are exploring the concept of warm-mix asphalt (WMA). WMA processes and products use various mechanical and chemical means to either reduce binder viscosity at lower temperatures or reduce the shear resistance of the mixture at construction temperatures while maintaining or improving pavement performance.

"We see the use of warm-mix asphalt technologies as a tremendous opportunity to improve construction quality, extend the construction season, and minimize negative impacts to the environment," says Peter Stephanos, P.E., director of FHWA's Office of Pavement Technology. "The collective effort of highway agencies and industry partners to advance warm-mix

At left, a truck receives a load of HMA heated to 320 °F (160 °C); on the right, a truck receives a load of WMA heated to 250 °F (121 °C). Note the greater visible air emissions from the HMA mixture being placed in the truck on the left.

asphalt technologies as a standard practice has been tremendous."

Warm-Mix Asphalt

The various asphalt mixtures are distinguished by the temperature ranges at which they are produced, and by the strength and durability of the final product. Manufacturers produce cold asphalt mixtures at ambient temperatures, in the 68–122 °F (20–50 °C) range. They produce HMA in the 284–338 °F (140–170 °C) range. HMA has higher stability and durability than cold-mix asphalt, which is why cold mix is used in the lower pavement layers of low-volume roadways. Manufacturers typically produce WMA in the 220–275 °F (104–135 °C) range.

Relative to HMA, the immediate benefit of producing WMA is its lower energy consumption. HMA requires high heat to enable the asphalt binder to become fluid enough to coat the aggregate completely, have workability during laying and compaction, and retain durability during traffic exposure. With WMA's lower production temperatures comes the additional benefit of reduced emissions from burning fossil fuels, and decreased fumes and odors, at the plant and paving sites.

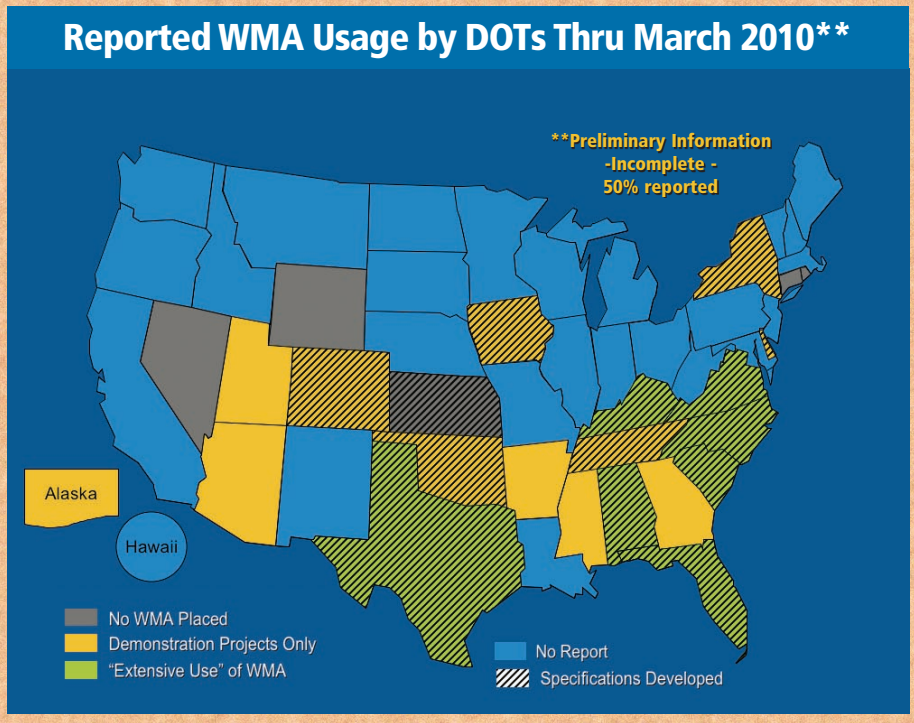
The differential between a production temperature established for an original HMA design and an alternative design using WMA technology only partially determines the reductions that are achieved. The final production temperature depends on more than a simple decision and turning down a dial. Other factors include the production plant capabilities; the tuning of the burner that heats the mix (to provide complete fuel combustion at the reduced production temperature), binder, and mixture design; and the specific WMA technology used.

History of WMA

Development of WMA technologies began in Europe in the late 1990s, prompted by the German Bitumen Forum, a broad coalition of industry, labor, and government to address asphalt material issues. In 1997, the European Union was in the process of adopting the Kyoto Protocol on climate change. Growing environmental awareness and activism by the public along with increased regulatory pressure to reduce greenhouse gas emissions prompted the forum to develop strategies to reduce air emissions.

The forum's Temperature Reduction Working Group evaluated technologies that save energy, reduce carbon dioxide production, and lower emissions by targeting temperature reductions of Gussasphalt (an asphalt rich in bitumen and limestone), which was traditionally produced at temperatures greater than 450 °F (232 °C)—a temperature much higher than those used in the United States for HMA. Similar initiatives to reduce temperatures soon began in France, the Netherlands, Norway, South Africa, and elsewhere.

In the United States, the National Asphalt Pavement Association (NAPA) soon became interested in these technologies and began communicating with the European asphalt pavement industry about WMA. For the 2003 World of Asphalt Trade Show and Conference, NAPA invited representatives from European companies to make presentations on WMA. The



The WMA Technical Working Group recently surveyed State highway agencies on their use of WMA and adoption of WMA specification language. This map estimates the extent of WMA use and specification development as of March 2010, based on responses from 24 agencies. *Source: FHWA.*

Future Research Topics for the Warm Mix Asphalt Working Group

- WMA plus recycled asphalt pavement, shingles, and/or crumb rubber
- Laboratory versus inservice field aging of WMA mixtures
- Conditioning criteria for mechanical testing of WMA
- Laboratory versus production aging of WMA mixtures
- Synthesis/collection of information on State department of transportation usage and implementation of WMA
- Understanding of the function of additives in WMA production and construction
- National evaluation program for WMA technologies
- Understanding of the role of asphalt foam in aggregate coating, workability, compaction, and long-term performance
- Quality control and acceptance testing for WMA mixtures
- Open graded friction course plus WMA

following year, NAPA and the Association of Equipment Manufacturers conducted a WMA demonstration project for the 2004 World of Asphalt Trade Show and Conference. That same year, FHWA, NAPA, and three warm-mix technology suppliers initiated a research project at Auburn University's National Center for Asphalt Technology (NCAT) on methods for reducing asphalt mixture production and placement temperatures.

"By 2005 it was obvious that WMA needed to be fully understood and adopted in the United States through a coordinated effort of asphalt pavement industry partners," says King W. Gee, associate administrator of the FHWA Office of Infrastructure.

FHWA and NAPA responded by forming the Warm Mix Asphalt Technical Working Group and tasked it with proactively providing national guidance in investigating and implementing WMA technologies. The group included multiple sectors of the asphalt pavement industry, such as State highway agencies, academia, and contractors. The group's longstanding goal is to provide technical WMA guidance that will lead to a product with quality, cost-effectiveness, and performance at least equal to conventional HMA.

The working group has developed recommendations on WMA technologies and statements on nationally significant research needs. The group's products include a Web site (warmmixasphalt.com), a guide specification for WMA highway construction, materials and emissions testing recommendations, a best practices document on WMA construction, and organization of the first International Conference on WMA.

"Warm-mix asphalt is the future of flexible pavements in the United States," says NAPA President Mike Acott. "It represents the next evolution of the asphalt industry's quest for continuous improvement. We have worked diligently with our partners to improve pavement performance through materials selection, mix design, and pavement design. Lowering our production and paving temperatures promises improved energy consumption, operations, and quality."

Other Avenues

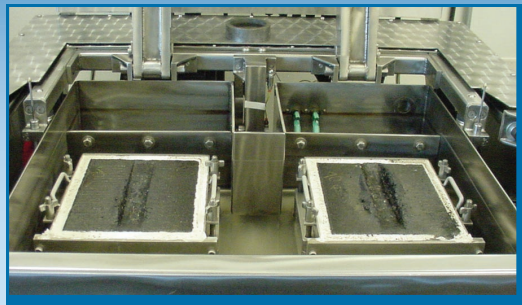
The American Association of State Highway and Transportation Officials (AASHTO) also has been active in implementation of WMA. Since 2006, AASHTO has approved five research needs statements and funded them through three National Cooperative Highway Research Program (NCHRP) projects: Project 09-43 Mix Design Practices for Warm Mix Asphalt; Project 09-47 Engineering Properties, Emissions, and Field Performance of Warm Mix Asphalt Technologies; and Project 09-49 Performance of WMA Technologies. In addition to continuing to develop research needs statements for future funding, the technical working group is focused on gathering detailed information on State WMA pavement projects and specification changes made to accommodate WMA technologies.

Although the original WMA technologies came out of Europe,

Mobile Asphalt Lab Testing

Since 2006, FHWA's Mobile Asphalt Lab has traveled to six WMA projects to conduct material sampling and testing, and mixture performance testing, with the asphalt mixture performance tester and Hamburg Wheel Track Device. The projects include the following:

A Missouri Department of Transportation (MoDOT) WMA demonstration project in St. Louis included construction of asphalt pavements using two additives and a water foaming product. The lab fabricated a large number of Superpave volumetric and asphalt mixture performance specimens for testing, in addition to loose mix sampled for later testing to investigate any effects due to reheating and residual moisture.



Hamburg testing on the WMA project in Colorado showed that the rutting results were equivalent for the HMA control (left photo) and one of the WMA technologies (right photo). They both exhibited similar rut depths when tested in accordance with Colorado Procedure – Laboratory 5112 Standard Method of Test for Hamburg Wheel-Track Testing of Compacted Bituminous Mixtures at a water bath temperature of 113 °F (45 °C) for the PG58-28 binder to 10,000 cycles. (Note: This was a 75 gyration mix design that CDOT typically does not subject to Hamburg testing requirements.) *Photos: CDOT.*

"MoDOT first experimented with WMA in 2006," says Dale A. Williams, P.E., a materials engineer at MoDOT. "Since then the use of WMA has grown steadily with a spurt in 2009 when several contractors purchased foaming equipment. In 2009 we placed 500,000 tons [453,600 metric tons] of WMA, which accounts for approximately 12.5 percent of all mix produced, and expect the use of WMA to continue to grow."

A Colorado Department of Transportation WMA project on I–70 near Dillon, CO, included construction of pavements using two additives and a water foaming product. The project location was on the uphill, eastbound lanes as the elevation climbs from 8,800 feet (2,682 meters) to 11,100 feet (3,383 meters) at the Eisenhower/Johnson Memorial Tunnel. The project included cooler, late season paving performed at night and at a high elevation, with a relatively soft performance graded binder, on an interstate facility that carries a high volume of truck traffic.

An FHWA Western Federal Lands Highway Division project in Yellowstone National Park in Wyoming placed a total of 30,000 tons (27,216 metric tons) of asphalt mixture, split between a traditional HMA control section and a WMA section using an additive and a

documented performance data were limited. In 2007, FHWA conducted an International Technology Scanning Program tour in cooperation with AASHTO and NCHRP. A team of 13 asphalt pavement materials experts assembled to assess and evaluate European WMA experiences and pavement performance. FHWA published the results of the scan as *Warm Mix Asphalt: European Practice* (FHWA-PL-08-007), which concludes: "The consensus among the scan team members was that WMA is a viable technology and that U.S. highway agencies and the HMA industry need to cooperatively pursue this path."

WMA Technologies

Since 2006 NCAT has documented more than 140 WMA projects in 43 States and the District of Columbia. In the same period, providers have introduced 21 named WMA technologies into the U.S. market. The technologies generally fall into three categories: materials processing, mixture and binder additives (chemicals and waxes), and water foaming technologies. Some technologies also include such additives as surfactants or chemical antistripping agents. All of these technologies, introduced at some point or other in the production process, make it easier for manufacturers and crews to make and place WMA pavements, and facilitate the pavements' performance and long lives.

FHWA is involved in evaluating and implementing these and other WMA technologies. The agency is working closely with State and industry partners to develop and monitor demonstration projects and research, and to advance the knowledge and state of practice of WMA materials and technologies.

State agencies have requested the services of FHWA's Mobile Asphalt Pavement Mixture Laboratory (Mobile Asphalt Lab) to support further research and validation through material sampling and performance testing on WMA projects. Experienced technicians and engineers travel with the mobile lab to pavement construction sites across the country to help transportation partners resolve national issues related to implementation of new pavement technologies.

Although the primary purpose of WMA has been to lower production temperatures, providers also market some WMA technologies as compaction aids. Crews use the technologies at traditional HMA temperatures to improve field compaction, provide more consistent pavement density across an entire pavement, or increase the final in-place density of the pavement. A less variable, better compacted asphalt pavement should have improved performance overall. As documented in *Volumetric Requirements for Superpave Mix Design* (NCHRP Report 567), better compacted asphalt pavements often have superior fatigue and rutting performance. Greater pavement density also can decrease the permeability of asphalt mixtures, which would decrease the amount of field aging in the mixture and cause less aging of the mixtures during production. The results suggest that WMA mixtures initially are less stiff when compared with the HMA control sections and are dependent on the production temperature and WMA technology used. As a result, the testing reveals lower flow number test values and deeper rut depths than the researchers normally would expect from traditional HMA pavements.

Agency and university researchers across the United States have used data from these projects to support multiple NCHRP projects and develop performance prediction models for WMA pavements.

water foaming product. The asphalt mixture haul distance was 50–55 miles (80–86 kilometers) from the mixture production plant. Longer haul distances provide an opportunity for HMA to encounter too much cooling of the mixture during transportation, which can make it difficult to place and compact. The WMA mixtures start at a cooler temperature and can be placed and compacted at lower temperatures than traditional HMA.

A Texas Department of Transportation project near Jasper, TX, was one of the first projects to combine a wax additive in addition to a chemical antistrip in one product.

Two Pennsylvania Department of Transportation projects near Centre Hall and Spring Mills, PA, utilized two HMA control sections and four WMA technologies—one additive and three water foaming technologies.

A MoDOT project on I–55 near Sikeston, MO, used a polymer-modified binder in conjunction with a water foaming technology.

In general, the Mobile Asphalt Lab's testing results have been able to distinguish the WMA technologies from the HMA control sections. The asphalt mixture performance tester's dynamic modulus master curves and flow number results and the Hamburg rut testing results show that the reduced production temperatures of WMA pavements

(Left) A work crew is using WMA to pave this section of the East Entrance Road inside Yellowstone National Park, WY, between the East Entrance Gate and Sylvan Pass in fall 2007. (Right) The completed road. *Photos: Brad Neitzke, Western Federal Lands Highway Division.*

improve performance in terms of cracking and moisture susceptibility.

Lower Temperature, Increased Moisture Susceptibility?

Reducing the production temperature of HMA without the additional implementation of materials handling and production best practices might lead to incomplete drying of the aggregate, which could have negative implications for pavement performance. There is concern that HMA pavements might be more susceptible to moisture if the aggregate is not completely dry, and early rutting could occur due to reduced production aging of the binder. There also needs to be a way to ensure the effectiveness and long-term performance of WMA technologies introduced into the marketplace.

To be sure, moisture damage is also possible in HMA mixtures, but it could be exacerbated in WMA due to production issues. Inadequately dried aggregates at lower production temperatures, plus the possible introduction of additional moisture (although small in amount, typically less than 1.5 percent of the weight of the binder) to the WMA from the various WMA foaming or emulsion technologies, creates a concern that moisture could displace asphalt in coating certain kinds of aggregate. This displacement could affect the asphalt binder-to-aggregate adhesion, increase asphalt stripping and moisture susceptibility, and generally reduce mixture performance.

The extent to which WMA technologies and additives affect moisture sensitivity will depend on a number of conditions, both regional (climate, aggregate type, and asphalt binder source) and pavement-specific (traffic loading, density, permeability, and general pavement integrity). This problem is not unique to mixes produced at lower temperatures, however, and in the past engineers have treated HMA effectively to resist stripping (when the liquid asphalt binder strips away from the aggregate it is coating due to the presence of moisture).

Reduced binder aging could reduce the cracking of pavement later in its life, although recent evaluations of in-place WMA pavements show they reach a similar aged condition as HMA pavements after 2 or 3 years in service. Another concern is that the reduced aging of WMA in the early stages of a pavement's life could contribute to loss of stability in hot weather and increase susceptibility to rutting. However, approaches to materials and mix type selection may provide effective solutions.

State departments of transportation can call on FHWA's Mobile Asphalt Lab, shown here, to help implement pavement technologies, as several have done with WMA applications.

Mixture design/selection strategies, such as increasing the high-temperature asphalt binder grade or selecting rut-resistant mixtures like stone matrix asphalt, are a couple of strategies being explored. Use of more angular aggregate will provide greater internal friction to the mix, which in turn increases its shear strength without only relying on the cohesion of the binder. Using a higher high-temperature, performance-graded binder—essentially grade bumping—can counteract the effects of reduced plant oxidation during mixing if it is needed.

Test data on moisture damage and rutting performance often show contradictory results between the laboratory testing versus the field. The Mobile Asphalt Lab, State agencies, and other researchers have found that in the lab WMA mixtures often fail to meet the Hamburg Wheel Tracking Device test criteria for maximum allowable rut depth when immersed in a conditioning water bath, yet moisture damage and rutting have not commonly been witnessed in the field.

Researchers report similar results (failures of WMA in the lab but not in the field) when using the AASHTO T 283 test procedure and comparing the tensile strengths—the greatest longitudinal stress a substance can bear without tearing apart—of WMA and HMA. In general, the WMA tensile strengths for both dry and conditioned specimens are lower than the HMA control specimens, and WMA specimens often do not pass the 80 percent tensile strength ratio typically required by most State agencies.

An evaluation of WMA projects by NCAT found that 16 of 27 ratios for WMA specimens that were compacted immediately without reheating did not meet the 80 percent minimum ratio. That is, the ratio of conditioned specimen strengths to dry specimen strengths was below 0.80, or the effects of being partially vacuum saturated, subjected to freezing, and soaked in warm water caused the tensile strengths to decrease by more than 20 percent. When NCAT compacted the specimens after reheating the mixture, 8 of the 27 did not meet or exceed the 80 percent minimum. Some of those constructed WMA pavements have shown raveling, which could indicate moisture damage.

These differences between laboratory test results and field performance suggest modifications to material preparation and/or test procedures might be required in the laboratory when evaluating WMA moisture damage and rutting susceptibility so that field conditions

NAPA

This field trial shows the difference in initial oxidation between HMA and WMA pavements. The lane paved with HMA, at left, shows grayness associated with production oxidation at high temperatures; the blacker lanes to the right were paved with WMA. The reduced mixture oxidation (or aging) due to reduced production temperatures is temporary, and field oxidation appears to approach traditional HMA pavements within 3 years.

can be simulated properly. However, this issue raises some immediate questions. Should WMA mixture testing require different conditioning or test procedures than HMA mixtures when researchers expect that WMA should perform equal to or better than HMA? If researchers change testing protocols, are the modifications appropriate for countrywide adoption? Or should the researchers make regional modifications to reflect differences in climate, traffic, and virgin materials?

An Even Better Environment for WMA?

Current and pending regulations regarding greenhouse gas emissions are making the consideration of greater reductions in HMA production temperatures more attractive. Although production plant emissions have decreased significantly over the last 35 years due to pollution controls, further reductions in greenhouse gases will likely be mandated in the future.

Many environmental factors are driving development and implementation of WMA technologies globally. Nevertheless, for WMA to succeed in the United States, pavements must have equal or better performance compared to traditional HMA pavements. Engineers must be satisfied that WMA mixtures will be as strong and durable as current pavements.

So far, the future looks bright. "The warm-mix asphalt technologies have shown great promise as a new standard for asphalt production," FHWA's Stephanos says. "At FHWA, we are committed to working with our industry, State, and academic partners to continue to monitor and evaluate the long-term performance of this technology."

In addition, technicians and construction personnel need to acquaint themselves with the characteristics and behavior of the new materials. Further research is needed to measure the degree of environmental improvement, fundamental mix characteristics, and impact on performance of the new technologies.

"WMA technology provides an important tool to the pavement engineer," says Pete T. Grass, P.E., president of the Asphalt Institute. "With the widespread test sections around the country, designers and contractors alike now have a great opportunity to learn more about this promising practice that is revolutionizing the paving industry in North America."

Matthew Corrigan is an asphalt pavement engineer with FHWA's Office of Pavement Technology. He is FHWA's coordinator for investigation and implementation of WMA technologies, cochairman of the Warm Mix Asphalt Technical Working Group, and manager of the Mobile Asphalt Lab. Corrigan is a graduate of The Pennsylvania State University with a degree in civil engineering and is a licensed professional engineer in the Commonwealth of Virginia.

Dave Newcomb is the vice president for research and technology at NAPA. He is a licensed professional engineer in Minnesota.

Thomas Bennert is the senior research engineer at the Center for Advanced Infrastructure and Transportation at Rutgers, The State University of New Jersey. He is a member of the WMA working group and the Transportation Research Board's Committee AFK30: Characteristics of Nonbituminous Components of Bituminous Paving Mixtures.

For more information, contact Matthew Corrigan at 202-366-1549 or matthew.corrigan@dot.gov, Dave Newcomb at 301-731-4748, ext. 104, or dnewcomb@hotmix.org, or Thomas Bennert at 732-445-5376 or bennert@eden.rutgers.edu.

Scour, Flooding, and Inundation

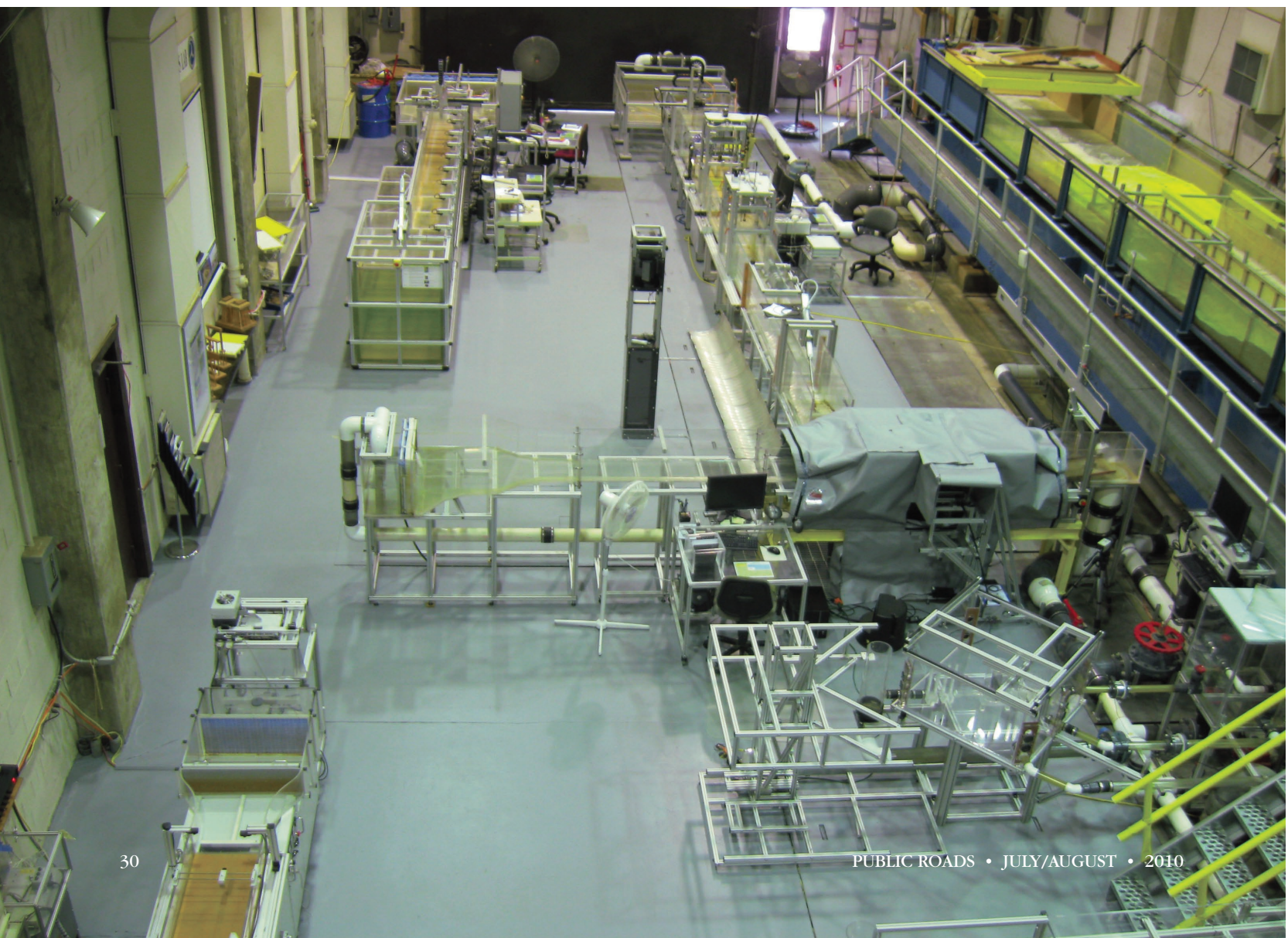
The FHWA hydraulics R&D program conducts advanced and applied research to mitigate disaster risks by addressing three of the main hazards.

by Kornel Kerenyi and Junke Guo

In recent history, flooding, coastal inundation, and scour of bridge piers and abutments have been among the leading causes of bridge failures in the United States. Recent examples of structures affected by flooding, inundation, or scour include the numerous bridges in New Orleans and along the Gulf Coast damaged by Hurricanes Katrina (2005) and Rita (2005), the damage to more than 2,400 bridge crossings during the 1993 Upper Mississippi River basin flooding, the 1994 failure of numerous bridges during Tropical Storm Alberto in central and southwest Georgia, and the 1987 failure of the I–90 bridge over the Schoharie Creek near Amsterdam, NY, which resulted in the loss of 10 lives and millions of dollars in bridge repair and replacement costs.

Given national costs due to scour-related damage, plus disruption to local economic activities from bridge closures, and the potential for devastating loss of life from floods and inundation, bridge foundations demand improved engineering analysis and design procedures to mitigate the consequences of natural disasters.

Researchers with the Federal Highway Administration (FHWA), under the Hydraulics Research program at the J. Sterling Jones Hydraulics Laboratory located at FHWA's Turner-Fairbank Highway Research Center (TFHRC), and their partners

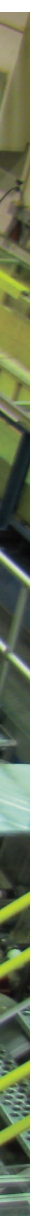


currently are conducting applied and exploratory advanced research to improve prediction of flooding-related damages and design guidance for mitigating impacts on bridges and other hydraulic structures.

Further, FHWA is collaborating with several laboratories and universities to help assure the program's success. For example, research partners at the Argonne National Laboratory's (ANL) Transportation Research and Analysis Computing Center (TRACC) in West Chicago, IL, and the Universities of Nebraska and Iowa are championing advanced engineering tools such as computational fluid dynamics to simulate extreme flood events and their interaction with bridge structures. Computational fluid dynamics uses numerical methods and algorithms to analyze and solve problems that involve fluid flows.

Past Research Contributions

The TFHRC hydraulics laboratory has been involved in a number of studies, including investigation of the Hatchie River Bridge collapse in Tennessee. Spans of the northbound U.S. Route 51 bridge over the Hatchie River collapsed on April 1, 1989. Five vehicles went into the river, and eight people were killed. To help determine the cause of the collapse, the National Transportation Safety Board (NTSB) asked FHWA to conduct hydraulic model studies of the two-column bent #70 with independent footings of the Hatchie River Bridge. Onsite investigation had established that failure of this bent probably triggered the collapse. The hydraulics laboratory tested a 1:20 scale model of the bent to determine how the maximum local pier scour might have occurred after the channel migrated to bent #70 and to obtain videotape shots of the local scour process for use as a visual aid in the NTSB public hearing conducted to gather evidence concerning the collapse.



(Left) FHWA's J. Sterling Jones Hydraulics Laboratory includes several testing flumes to conduct flooding-related research studies, including a tilting flume (on the far right), a force balance flume (next to the tilting flume), and a tilting fish passage culvert flume (center). Two other flumes are perpendicular to those flumes.

Hydraulics Laboratory Facts

The J. Sterling Jones Hydraulics Laboratory features multiple hydraulic flumes of varying functions and sizes. Most prominent of these flumes is a 6-foot, ft (1.8-meter, m)-wide by 70-ft (21.3-m)-long tilting flume with a sediment recess for local scour modeling and a total pumping capacity of 15 cubic feet per second (ft^3/s), 425 liters per second (L/sec), with variable-frequency drives capable of simulating in-flow hydrographs. Adjacent to the tilting flume is a 1.3-ft (0.4-m)-wide by 42-ft (12.8-m)-long force balance flume capable of measuring horizontal, vertical, and rotational forces on an object, a shear stress sensor at the base of the flume, 12 ultrasonic depth sensors used to measure water elevation at multiple locations along the tank, and a wave generator capable of inducing multiple wave patterns at varying heights and intensities. The facility also includes several particle image velocimetry (PIV) testing stations capable of recording 2-dimensional (2–D), 3-dimemsional (3–D), and 3-component (3–C) 3–D PIV data. The hydraulics laboratory also includes a 1.3-ft (0.4-m)-wide by 26.2-ft (8-m)-long tilting fish passage culvert flume to test low-flow entrance loss coefficients and to evaluate roughness coefficients for low flows. In addition, the lab contains an ex situ scour testing device to investigate hydraulic loading on cohesive soils samples. The soil samples are mounted on a shear and normal force balance to measure the soil erosion response.

In another example of past research, the TFHRC laboratory conducted small-scale scour tests for the Woodrow Wilson Memorial Bridge replacement. The researchers tested 31 different model scenarios in the tilting flume and conducted 71 test runs with durations of 46 hours each. The scour evaluations were part of the process that led to design changes that saved millions of dollars. The savings resulted from reducing the predicted scour depths by an average of 15 to 20 feet (4.5 to 6 meters) for approximately 648 of the piles, using fewer but larger piles, and incorporating vertical piles instead of battered piles, which are more difficult and expensive to install, for the very deep foundations. Savings also resulted from reductions in equipment costs and the time needed for construction. Engineers gained a greater understanding of how pier protection systems for vessel impact, which are placed around the bridge's foundations to prevent collisions, affect the scouring process. After the researchers found that the proposed position of the pier protection system would double the amount of scour, the design was changed.

Applied Hydraulics Research

When a bridge crossing over a waterway is partially or entirely submerged during a flood, the deck might be subjected to significant hydrodynamic loading. In addition, the pressurized accelerated flow can create severe potential for scour because scouring the channel bed is one of the only ways for a river to dissipate energy and reach equilibrium when it is carrying a given discharge under pressurized flow.

To address these issues, the hydraulics research and development (R&D) program at TFHRC conducted two studies in fiscal years (FY) 2008 and 2009—one on hydrodynamic forces and the other on pressure flow scour—using small-scale physical experiments and computational fluid dynamics-based simulations.

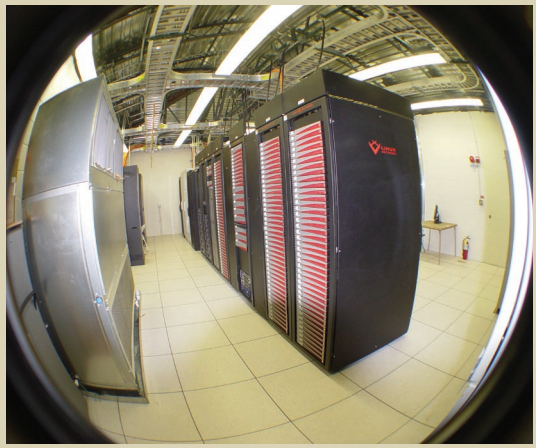
The results of the first study are new charts for bridge designers to use when estimating hydrodynamic loading. The FHWA Hydraulic Design Series 1 (HDS-1), *Hydraulics of Bridge Waterways* (FHWA-EPD-86-101), will be updated to incorporate the new charts. One of those design charts, for example, compares experimental data with the simulation results for drag forces (drag coefficients), which act in a direction opposite to the oncoming flow velocity.

The outcome of the second study will be included in the new edition of FHWA's Hydraulic Engineering Circular No. 18 (HEC–18) *Evaluating Scour at Bridges* (FHWA NHI 01-001). The upcoming edition will include a new design chart for estimating pressure flow scour as a function of the inundation number. Over its lifespan, any given bridge will likely be inundated or submerged for a short period of time. The study analyzed the impact (that is, the scour) on the riverbed if a bridge is submerged or inundated under pressurized flow. This pressure flow scour has to be considered in the design of the bridge foundation

TRACC Computing Facility

The FHWA hydraulics laboratory's numerical modeling occurs at the Argonne National Laboratory's (ANL) Transportation Research and Analysis Computing Center (TRACC). TRACC is studying computational fluid dynamics-based simulation techniques. Engineers compare these simulations to tests conducted at the hydraulics laboratory.

The U.S. Department of Transportation (USDOT) and ANL established TRACC as a general purpose advanced computing and visualization facility available for use by the transportation community for a variety of applications. Staff from USDOT's Research and Innovative Technology Administration and FHWA identified specific initial applications and technologies that should have highest priority for research and development (R&D) and user support.



Argonne National Laboratory

This TRACC parallel computing system provides researchers with the visualization capabilities necessary for their experiments.

The TRACC components include high-performance computing, visualization, and networking systems. To take advantage of ANL's extensive experience in the acquisition and operation of similar user facilities, the system components were installed in dedicated facilities at the DuPage National Technology Park near the DuPage County Airport in Illinois. The TRACC computational cluster is a 512-core, customized system that comprises 128 compute nodes, each with two dual-core central processing units (CPUs) and 4 gigabytes of random access memory (RAM); a storage system consisting of 240 terabytes of shared redundant array of independent disks (RAID) storage that is expandable to 750 terabytes; a high-bandwidth, low-latency network for internode computations; and a high-bandwidth management network. The center also offers scientific visualization capabilities through the TRACC facilities at the same location. The scientific visualization facilities meet the needs for visualization of multidimensional data via a high-performance graphics cluster linked with a 15-panel liquid crystal display (LCD)-tiled display and a portal optimized for visual simulation and high-speed broadband connectivity.

and will affect the depth at which the footings are placed.

This study researched clear water scour, which is defined as scour of a riverbed when the water cannot transport sediment because the flow is too slow and therefore not powerful enough to suspend particles long enough to carry them downstream—a rare situation in the field. Most floods are sediment-laden flows where the water's capacity for sediment transport governs the amount of scour. During most storms, field flow velocities and stream power are extremely high, so upstream sediment from the riverbed moves rapidly downstream toward any infrastructure. This latter phenomenon is called live bed scour, as opposed to clear water scour. The TFHRC researchers analyzed clear water scour first to set a baseline and will address live bed scour in the research's second phase.

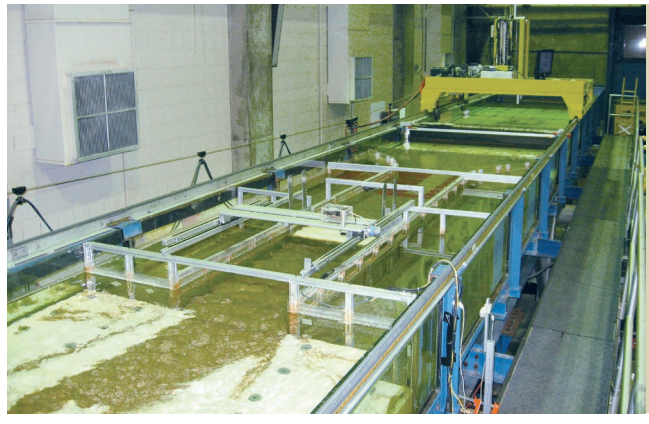
Four New Studies for 2010

The hydraulics R&D program's team plans four new research studies to be initiated at the TFHRC laboratory in FY10 and completed in subsequent years.

The first study is a continuation of the FY08 and FY09 completed research on pressure flow scour, which addressed only clear water scour. The proposed study will extend current pressure flow scour predictions into the live bed scour range, utilizing a new flume at TFHRC that allows high-speed live bed scour tests.

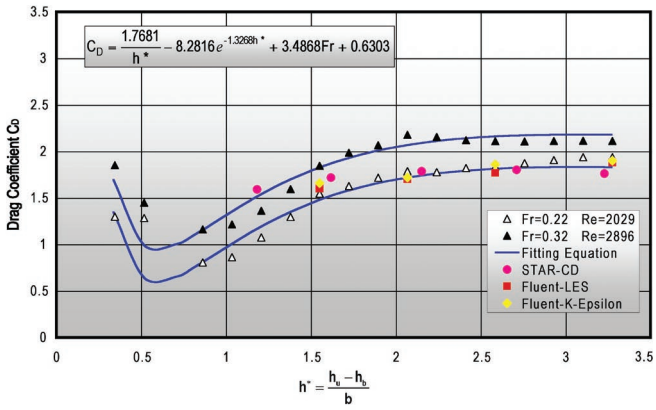
This research also will study the influence of bridge piers on pressure flow. The current practice assumes a linear superimposition of general, contraction, and local pier scour. The latter is caused by vortices formed at the base of piers due to the pileup of water on their upstream surfaces and subsequent acceleration of flow. But these assumptions might not be applicable because of nonlinear interactions between local pier scour and general scour under pressure flow conditions. Hence, this research will improve understanding of the nonlinear effects on local pier scour under pressure flow conditions.

The second study will address the initial erosion process of cohesive soils. Scour of cohesive soils is a complex phenomenon that is not well understood. This study will apply various hydraulic loading conditions (flow velocities) to different cohesive soils and measure the erosion responses. The hydraulic loading is performed using an ex situ scour testing device that produces what are known as Couette flow conditions, using a moving belt in still water over riverbed cohesive soil samples. The gap between the samples and the belt is 0.59-inch (15-millimeters). Couette flow conditions refer to the laminar flow of a viscous fluid in the space between two parallel layers, one of which is moving relative to the other. The velocity distribution in the gap is approximately S–shaped. The riverbed cohesive soil samples are mounted on a force



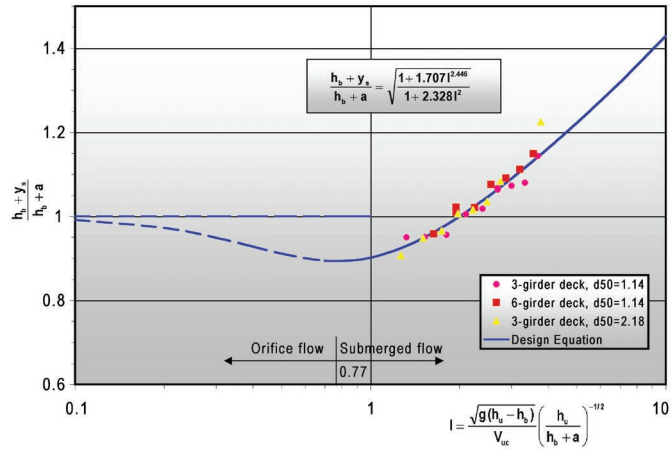
Shown here is the hydraulics lab's tilting flume during a pressure scour experiment in which a bridge deck is mounted in about one-third of the flume's width. The yellow carriage over the flume holds several devices to measure the flow velocity, bed elevation, and other variables. The flow is from the top right to the bottom left, and the eroded sands are moving downstream from the test section.

Drag Coefficient Profiles



This graph shows experimentally determined and computer-simulated drag coefficients versus the inundation ratio for a six-girder bridge deck model. The chart shows that the drag coefficient is constant for higher inundation ratios. *Source: FHWA.*

Pressure Flow Scour Design



This graph shows the experimentally determined maximum scour depth ratio versus the inundation number for a six-girder bridge deck and a three-girder deck model using two different sediment size diameters. The blue line represents the new pressure flow scour design equation and shows a good fit to the measured data. The chart also shows that the maximum scour ratio increases with higher inundation numbers. *Source: FHWA.*

balance sensor that can measure horizontal (shear) forces and vertical (normal) forces during erosion.

The third study will analyze the effect of pier scour and pressure flow scour on coarse bed material. If riverbed material has more large sand particles than fine sand, pier scour will be reduced because large particles will withstand the hydraulic dislodging forces and therefore armor the scour hole. If the particle distribution consists of more fine sand than large particles, pier scour will be greater. This research will study the influence of sand particle distribution on bridge pier scour. The goal is to develop an improved scour reduction (adjustment) factor for coarse sand particle distribution by revisiting and improving the methodology suggested in HEC–18, a methodology that is difficult to apply.

The research study will consist of laboratory experiments, field data, and computational fluid dynamics simulations to derive a new adjustment factor. The influence of gradations of bed material, such as gravel, sand, and fine sediment, will be expressed in terms of an improved critical velocity equation and a more accurate gradation coefficient of the bed material, enabling the designer to compute the scour adjustment factor to obtain a more accurate overall scour estimate.

The fourth study for FY10 relates to analyzing the magnitude of buoyancy or uplift forces on culverts. Many culvert failures occur when a culvert is submerged with air trapped inside. The resulting buoyancy or uplift forces can be of such magnitude that the whole culvert system is pushed upwards and fails. This study will investigate culverts during subcritical flow (full flow conditions), with air trapped in the flow separation zone at the culvert inlet. The researchers will mount culvert models on a carefully designed force balance system (an array of force sensors—load cells—measuring the changes in forces) that will include tension coil springs with load cells supporting the culvert models. The researchers will use the change in spring tension to estimate the uplift forces. Computational fluid dynamics modeling will augment the culvert buoyancy experiments by converting the measured forces into uplift coefficients that the researchers then will use to develop design guidelines to be applied in the field.

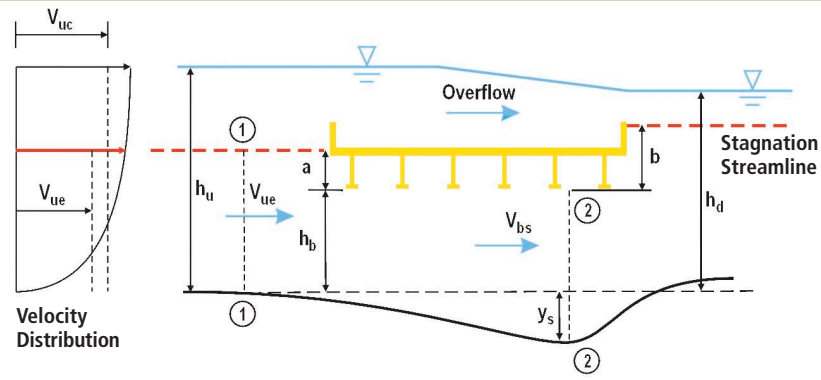
Advanced Hydraulics Research Program

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. (To learn more about the EAR Program, visit www.fhwa.dot.gov/advancedresearch.)

In August 2007, FHWA convened an international hydraulics research forum, gathering researchers and other stakeholders to stimulate advanced research in hydraulics and identify research priorities. The forum drew experts from universities, industry, and government transportation agencies, who reported on a broad spectrum of ongoing investigations and specific research needs. Discussion centered around three major areas of hydraulics research—coastal, inland, and environmental—and the need to establish communications, partnerships, and future directions. Two topics warranted special attention: advanced modeling capabilities (physical, numerical, and supercomputing) and the implications of climate change for the field.

According to Jorge E. Pagán-Ortiz, director of FHWA's Office of Infrastructure Research & Development, "The participants emphasized the importance of collaboration to maximize scarce funding and data-sharing to accelerate the progress

Definition Sketch of Symbols



a	=	Effective Thickness of Deck Blockage	h*	=	Inundation Ratio
b	=	Physical Thickness of Deck Blockage	I	=	Inundation Index
Fr	=	Froude Number	Re	=	Reynolds Number
g	=	Gravitational Acceleration	V_{bs}	=	Velocity Through Bridge After Scour
D_{50}	=	Median Diameter of Sand	V_{uc}	=	Upstream Critical Approach Velocity
h_b	=	Inundation Depth Before Scour	V_{ue}	=	Upstream Effective Velocity Through a Bridge
h_d	=	Downstream Flow Depth Before Scour	y_s	=	Maximum Scour Depth
h_u	=	Upstream Flow Depth Before Scour			

This definition sketch shows a cross section of a model six-girder bridge deck tested during the TFHRC hydrodynamic forces and pressure flow scour studies. The sketch defines the direction of the flow, the upstream velocity profile, and the position of the maximum scour observed when a bridge deck is submerged. *Source: FHWA.*

of research. They recommended that annual or biennial hydraulics research forums be organized, a Web site be created for reporting and peer-reviewing hydraulics research, and a steering committee, working groups, and collaborative relationships be formed for planning and conducting research."

Among the high-risk topics with long-term potential discussed at the forum, participants called for research into applications of "smart materials," such as in integrated scour-monitoring systems. They also recommended development of hydrodynamically efficient bridge pier and deck systems, plus structures that can adapt optimally to flow conditions through the use of adaptive materials based on nanotechnology and biomimetics, which is the study and emulation of nature's models, systems, processes, and elements to solve engineering problems.

Forum participants identified two areas of high-risk, high-payoff research for the near term: development of smart particles for monitoring hydraulic hazards and scour countermeasures using advanced materials based on nanotechnology.

Two EAR-sponsored joint investigations are underway that address these study areas. Led by researchers at FHWA's hydraulics laboratory in collaboration with experts from the National Aeronautics and Space Administration's Jet Propulsion Laboratory, the first of the two joint studies is exploring new ways to measure and understand the complex flow fields and boundary pressure fields associated with bridge pier scour. This project is pursuing an integrated, flexible, sensing system that can measure changes in shear stress and pressure when a scour hole forms. Such a system would significantly aid small-scale experiments to address bridge scour problems by allowing the measurement of forces that occur during the scouring process. Measurement of those forces is necessary for the development of advanced scour countermeasure materials, which might have nanotechnology components.

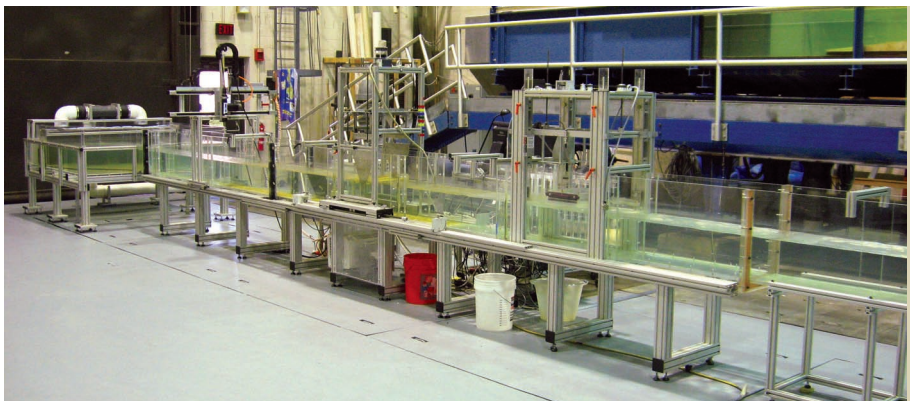
The second joint project is working toward an advanced optical system to allow three-dimensional measurement of the entire instantaneous flow field around bridge pier models. The high-resolution, volumetric particle image system will be able to capture and quantify complex, unsteady flow fields in experimental bridge-scour research. Also led by the hydraulics laboratory, this joint study will enable hydraulic researchers to develop more precise models for predicting scour. This study will allow visualization of the complex, three-dimensional flow field around bridge piers during scouring. To predict the forces during the pier scouring process, the researchers will compare these flow fields with the computational fluid dynamics simulations performed at ANL.

Following the first international hydraulics research forum's recommendation for development of intelligent piers, the EAR Program convened a 1-day market research meeting in June 2009 to explore the potential of wireless, smart particle sensor networks for hydraulics research and monitoring. Such sensors would be capable of transmitting data on position, velocity, pressure, and other variables under a wide range of environmental conditions.

Five research laboratories presented their ideas at the market research meeting, and a government review panel developed recommendations for moving forward. The panel consisted of experts from the U.S. Army Corps of Engineers, National Institute of Standards and Technology, U.S. Geological Survey, U.S. Naval Academy, and Oak Ridge National Laboratory. The panel recommended that a problem statement and a performance standard be developed as the basis for a full feasibility analysis. The panel members identified a number of challenges—concept validation, data accuracy, cost-benefit considerations, reproducibility, scope of application, and potential environmental impacts—and suggested that a research roadmap be developed as well. The panel also called for a followup meeting that would include a broader array of university and industry researchers.

Future Efforts and Expected Outcome

The applied FHWA hydraulics R&D program and its state-of-the-art laboratory will continue to conduct a variety of experiments pertaining to the characterization and potential impacts that flowing water can have

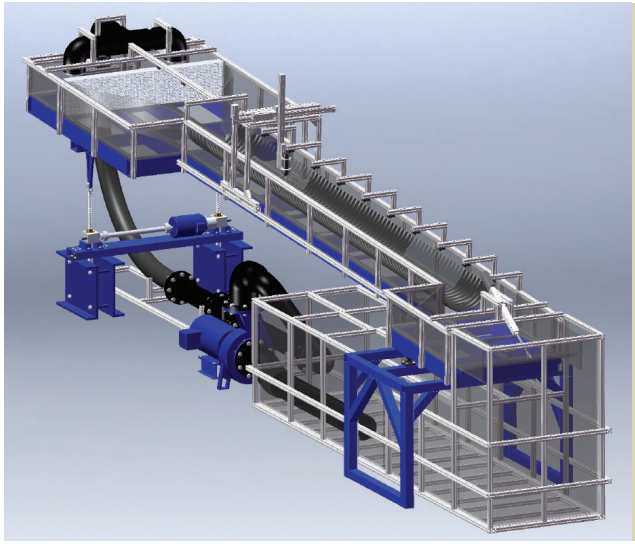


This photo of the hydraulics lab's force balance flume shows a rectangular system in the center that measures the horizontal, vertical, and rotational forces acting on a bridge deck when it is partly or fully submerged during a large flood. Beneath that measurement system is a shear stress sensor on the flume bottom that measures the boundary shear stress. To the right is a wave simulator that can generate waves with varied heights and intensities.

on the performance of the Nation's surface transportation infrastructure. For example, the laboratory will continue to solve stream stability problems, as the TFHRC researchers did in the *Bottomless Culvert Scour Study* (FHWA-HRT-07-026), which improved an existing methodology for estimating scour in bottomless culverts and measures to reduce that scour. The lab also will continue to develop design standards for bridges that might become submerged in high-flood-risk areas, as well as contributing to design standards concerning scouring around bridge foundations and submerged decks. The laboratory also will continue to support practitioners and engineers with design guidance and tools, as in *Effects of Inlet Geometry on Hydraulic Performance of Box Culverts* (FHWA-HRT-06-138).

In addition, the advanced FHWA hydraulics R&D program will continue to work on promising, high-risk, high-payoff projects in transportation-related hydraulics research, guided by the multiyear strategic plan formulated as the result of the first international hydraulics research forum. The plan proposes to move away gradually from physical experiments and use more computational fluid dynamics modeling to develop design guidance for bridge designers. Successful collaboration between ANL-TRACC and the FHWA hydraulics R&D program is the first step in that direction.

Pagán-Ortiz predicts, "Future research will also lead to progress in many areas: development of rapid deployment smart sensing systems to capture hydraulic parameters during storm events, development of enhanced analytical and modeling capabilities [high-performance computing] for predicting hydraulic hazard effects and for assessing and screening stream stability and scour countermeasures, development of enhanced scour analysis capabilities and countermeasures for inland and coastal bridges, environmentally advanced hydraulic designs and designs that facilitate fish and wildlife passage through hydraulic structures, and development of prefabricated hydrodynamic bridge decks and bridge piers. Research also will focus on how climate change will potentially impact the hydrologic and hydraulic procedures used for designing new surface transportation structures and evaluating the performance and condition of existing structures."



This schematic shows the lab's fish passage culvert tilting flume with a central test section and a built-in black corrugated aluminum culvert. This flume has the capability to recirculate the water, which can be stored in a tank underneath the flume. When the flume is running, the flow is from the top left to the bottom right. A jack underneath the inlet tank can lift the whole flume and, together with a hinge underneath the outlet section, can generate a slope of 2.6 degrees.

Kornel Kerenyi is a hydraulic research program manager in the FHWA Office of Infrastructure R&D. He coordinates FHWA's hydraulic and hydrology research activities with State and local agencies, academia, and various partners and customers, and he manages the hydraulics laboratory. Kerenyi holds a doctorate in fluid mechanics and hydraulic steel structures from the Vienna University of Technology in Austria.

Junke Guo is an assistant professor in the department of civil engineering in the Peter Kiewit Institute at the University of Nebraska–Lincoln. He received his Ph.D. in fluid mechanics and hydraulics from Colorado State University. His research interests include turbulent boundary layer flows, open-channel turbulence and sediment transport, computational fluid dynamics, and environmental fluid mechanics.

For more information, contact Kornel Kerenyi at 202-493-3142 or kornel.kerenyi@dot.gov, or Junke Guo at 402-554-3873 or junkeguo @mail.unomaha.edu.

Along the Road

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

Management and Administration

USDOT Launches Enforcement Pilot Programs on Distracted Driving

As part of its continuing effort to combat distracted driving, USDOT recently launched pilot programs in Hartford, CT, and Syracuse, NY, to test whether increased law enforcement efforts can deter drivers from using their cell phones. The pilot programs are the first federally funded efforts in the country to focus specifically on the effects of increased enforcement and public advertising on reducing distracted driving.

During the pilots, law enforcement officials will pull over and ticket drivers caught texting or talking on a handheld cell phone. The program's message is simple, "Phone in One Hand. Ticket in the Other." High-visibility enforcement began in the Hartford and Syracuse metropolitan areas in April 2010, and subsequent enforcement waves in both States will take place throughout the yearlong programs. A paid advertising campaign will support the pilots in both States.

Each pilot program received $200,000 in Federal funds and a matching $100,000 contribution from the State. Researchers will study changes in attitudes and behavior before and after the pilots, and the results will serve as a model for employing high-visibility enforcement, education, and outreach to reduce distracted driving across the country.

For more information, visit www.distraction.gov.

Policy and Legislation

USDOT, EPA Set New Fuel Economy Standards for Cars, Light Trucks

In April 2010, USDOT and the U.S. Environmental Protection Agency (EPA) established new Federal rules that set the first national greenhouse gas (GHG) emissions standards. The rules will significantly increase the fuel economy of all new passenger cars and light trucks sold in the United States. The new standards potentially could save the average buyer of a 2016 model-year car $3,000 over the life of the vehicle and, nationally, will conserve about 1.8 billion barrels of oil and reduce nearly a billion tons of GHG emissions over the lives of the vehicles.

Issued by USDOT's National Highway Traffic Safety Administration (NHTSA) and EPA, the rules establish fuel economy standards under NHTSA's Corporate Average Fuel Economy program and GHG emissions standards under the Clean Air Act for 2012–2016 model-year vehicles. Starting with 2012 model-year vehicles, the rules require automakers to improve fleetwide fuel economy and reduce fleetwide GHG emissions by approximately 5 percent each year.

The joint final regulation achieves the goal set by President Barack Obama to develop a national program to establish Federal standards that meet the needs of the States and the Nation as a whole to conserve energy and reduce GHG emissions. Cars, sport utility vehicles, minivans, and pickup trucks are responsible for almost 60 percent of all U.S. transportation-related GHG emissions.

Public Information and Information Exchange

Traffic Fatalities Reach Record Low in 2009

Statistics recently released by USDOT indicate that the number of overall traffic fatalities reported at the end of 2009 reached the lowest level since 1954, declining for the 15th consecutive quarter. According to early projections, the fatality rate, which takes into account the number of miles traveled, reached the lowest level ever recorded.

The projected fatality data for 2009, gathered by NHTSA, places the highway fatality count at 33,963, a drop of 8.9 percent compared to the 37,261 fatalities reported in 2008. The fatality rate for 2009 declined to 1.16 fatalities per 100 million vehicle miles traveled (VMT) down from 1.25 fatalities per 100 million VMT in 2008.

Although USDOT officials are encouraged by the drop and continuing trend, they remain steadfast in their determination to make the Nation's roadways safer. According to NHTSA Administrator David Strickland, "We will not stop as long as there are still lives lost on our Nation's highways. We must continue our efforts to ensure seatbelts are always used and stay focused on reducing distracted and impaired driving."

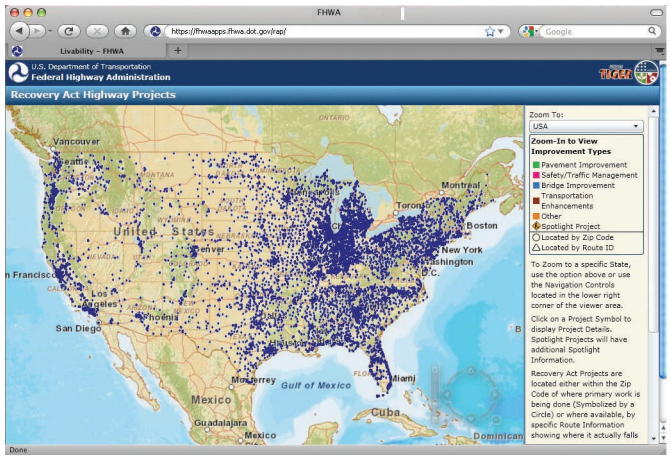
NHTSA attributes the decline in 2009 to a combination of factors that include high visibility campaigns, such as "Click It or Ticket," which aims to increase seatbelt use, and "Drunk Driving. Over the Limit. Under Arrest.," which helps to enforce State laws to prevent drunk and distracted driving. In addition, NHTSA credits safer roads, safer vehicles, and motorists driving less.

For more information and to download the report, visit www-nrd.nhtsa.dot.gov/Pubs/811291.PDF.

FHWA Map Shows Road Projects Funded by Recovery Act

FHWA has created an interactive map of the United States that shows the location of more than 12,000 road projects funded by the American Recovery and Reinvestment Act of 2009 (ARRA). The map features color-coded symbols corresponding to project type and enables users to zoom in to see details, including brief project descriptions and funding amounts.

The projects are located either within the ZIP Code where the primary work is being done—indicated on the map as a circle—or when available, by specific route information—indicated by a triangle. To view this information, map users can manipulate the map in a



FHWA created this interactive map showing the location of ARRA road projects.

number of ways: accessing a drop-down menu that zooms in by State, double-clicking on the specific area to zoom in, or using onscreen navigation controls. Once the map zooms in on an area, the projects are distinguished by type, including pavement improvement, safety/traffic management, bridge improvement, transportation enhancements, other, and "spotlight project," a featured project in each State.

To view the map, visit https://fhwaapps.fhwa.dot.gov/rap/.

National Bike Summit Stresses Importance Of Nonmotorized Transportation

In March 2010, more than 720 people gathered in Washington, DC, for a 3-day summit to discuss the needs of bicyclists in federally funded road projects. Discussions focused on discouraging transportation investments that negatively affect cyclists and pedestrians, and encouraging investments that go beyond the minimum requirements to provide facilities suitable for bicyclists and pedestrians of all ages and abilities.

Several high-ranking USDOT officials addressed participants during the summit. During an opening session, Peter Rogoff, administrator of the Federal Transit Administration, reassured attendees that the Department has a shared mission to provide transportation alternatives that include bicycling and public transit. At the closing reception, U.S. Secretary of Transportation Ray LaHood thanked summit participants for being advocates for livable, sustainable, bike-friendly communities.

The summit featured more than 40 presentations such as NYC Transportation Alternatives; Transportation Policy & Health: Building for a Healthy America; Bicycling to the Federal Workplace; Keeping Youth Rolling on the Right Path; Driver Distraction: Overview of the Problem & NHTSA Activities; Maximizing the Role of Bicycle Retailers in Local Advocacy; Commuter Benefits for the Bicycle Commuter; How Bicycling Can Boost Public Transit; and Colleges, Universities, Biking, and Climate Change.

Grants Help Provide Training for Transportation-Related Careers

FHWA recently awarded millions of dollars in job training grants for underrepresented or disadvantaged people pursuing careers in transportation, engineering, or construction. FHWA distributed the awards, made possible by ARRA, through its On-the-Job Training Supportive Services (OJTSS) and Disadvantaged Business Enterprises/Supportive Services (DBE/SS) programs.

The OJTSS program promotes training opportunities for women and minorities who continue to be underrepresented in the highway construction industry's skilled and semiskilled crafts, such as masonry and carpentry. For example, the OJTSS program helped support Virginia's Wounded Veterans Internship Program, which helps wounded active-duty military personnel sharpen their job skills and develop new ones while they recuperate.

The DBE/SS grants are part of an ongoing effort to help State DOTs train certified DBE firms—small businesses owned by minorities, women, or economically disadvantaged individuals—on subjects ranging from contract and business management to procurement assistance and how to secure bonding. The goal of the program is to help these businesses successfully compete for Federal highway projects.

FHWA Wins Engineering Excellence Silver Award

FHWA and the National Highway Institute accepted an award from the American Council of Engineering Companies of New York (ACEC New York) for creating the first national, comprehensive technical manual for the design and construction of tunnels. The manual earned FHWA the Engineering Excellence Silver Award in the category of Studies, Research and Consulting Engineering Services.

The Engineering Excellence Awards Program recognizes and celebrates achievements that demonstrate the highest degree of skill and ingenuity among member firms. ACEC New York presented the award to FHWA during a ceremony in New York City on March 27, 2010.

George A. Munfakh (left), senior vice president at Parsons Brinckerhoff (FHWA contractor), and Firas Ibrahim, a team leader in FHWA's Office of Infrastructure Research and Development, accept an Engineering Excellence Silver Award.

The award-winning *Technical Manual for Design and Construction of Road Tunnels—Civil Elements*, published in March 2009, provides guidelines for planning, design, construction, and rehabilitation of various types of road tunnels. The scope of the manual is primarily limited to the civil elements—that is, the nonmechanical elements including all structural and geotechnical items—of tunnels.

For more information, visit www.fhwa.dot.gov/bridge/tunnel/pubs/nhi09010/index.cfm.

Florida DOT Studies Innovative Marketing For Public Transportation

The Florida Department of Transportation released a report in February 2010 that explores the potential uses, applications, and marketing and communications potential of social media for the public transportation and travel demand management (TDM) industries. The study identified marketing techniques already being used by the public transportation industry and solicited ideas for unconventional applications that transit agencies and TDM professionals can consider implementing.

The report addresses social media tools including social networks, blogs, audio/video blogs, microblogs (such as Twitter), photo and video sharing, mobile applications, and user-generated content. For each medium, the report provides terminology definitions, benefits and drawbacks, strategic recommendations for transit use, and best practices. In addition, it examines specific examples of applications for the public transit and TDM industries. For example, the section on blogs features a list of links to popular transportation-related blogs, including the official blog of the U.S. Secretary of Transportation.

The study also resulted in a guidebook and Web site to help transit agencies navigate the various social media tools. The guidebook, complete with embedded links to various resources, provides instructions on how agencies can use the media tools and describes the projected benefits. The accompanying Web site, www.GoSocialTransit.com, provides an overview of each tool and links to industry applications.

For more information and to download the report, visit www.dot.state.fl.us/research-center/Completed_Proj/Summary_PTO/FDOT_BD549-53_rpt.pdf.

Florida Department of Transportation

Personnel

FHWA Names First Hispanic Woman To Lead Division

In January 2010, FHWA named Irene Rico to head its Virginia Division Office. Rico is the first Hispanic woman in the Agency's history to hold such a position.

Virginia Division Administrator Irene Rico.

Rico's career with FHWA began in 1985 as a highway engineer trainee. Later, she served in FHWA's New Mexico and Texas division offices, and eventually with the Virginia division as the assistant division administrator. Since 2007, Rico served as the special assistant to the executive director where she advised FHWA leadership on transportation policy and played a key role in implementing ARRA's $26.6 billion highway program.

As division administrator, Rico will oversee Virginia's use of more than $1 billion in Federal aid and ARRA funding for highways and bridges.

Reporting Changes of Address

PUBLIC ROADS has two categories of subscribers. One includes the organizations and people who receive the magazine without charge; the editorial office of the magazine maintains the mailing list for this group. The other category is the group of people and companies that pay to receive the magazine; the mailing list for this group is maintained by the Superintendent of Documents for the U.S. Government Printing Office.

Free copies are distributed to offices of the Federal Highway Administration, State highway agencies, technology transfer centers, and selected leaders who have responsibility for highway-related issues. Most of these copies are mailed to offices for their internal distribution or to people by position title rather than by name. If any office or individual subscriber in this category has a change of address, please send the complete previous mailing address and the complete new address to our distribution manager, Martha Soneira, via email (martha.soneira@dot.gov), telephone (202–493–3468), or mail (Martha Soneira, PUBLIC ROADS Distribution Manager (HRTM), Federal Highway Administration, 6300 Georgetown Pike, McLean, VA, 22101-2296).

Paid subscribers who have an address change should notify the U.S. Government Printing Office, Claims Office, Washington, DC, 20402; or call 202–512–1800; or fax 202–512–2168. Please do not send an address change for a paid subscription to the editorial office of PUBLIC ROADS. We do not manage the paid subscription program or mailing list, and we are not able to make the requested change.

Internet Watch

by Alicia Sindlinger

Living Up to the Livability Challenge

Concerns about environmental quality, economic prosperity, and social equity continue to fuel the push for more livable communities at the local, State, regional, and national levels. In June 2009, the U.S. Department of Housing and Urban Development (HUD), the U.S. Department of Transportation (USDOT), and the U.S. Environmental Protection Agency (EPA) formed an Interagency Partnership for Sustainable Communities, an unprecedented agreement to ensure that housing and transportation goals are met while simultaneously protecting the environment, promoting equitable development, and helping to address the challenges of climate change.

For USDOT, the concept of "livability" focuses on tying the quality and location of transportation facilities to good jobs, affordable housing, quality schools, and safe streets. Enhancing livability, in part, also means ensuring that roads provide safe mobility for all travelers—not just motor vehicles. (For more information, see "Complete Streets" on page 12 in this issue of PUBLIC ROADS.)

To support the partnership and help advance livable communities initiatives, the Federal Highway Administration (FHWA) developed the Livability Initiative Web site at www.fhwa.dot.gov/livability. The site provides updates on the partnership and centralizes FHWA's livability-related resources.

"Livability is in a brighter spotlight than ever before," says Gabriel Rousseau, acting team leader of FHWA's Office of Human Environment, Livability Team. "It is a priority of the current Administration and one that we take very seriously. With the Livability Initiative Web site, we're bringing together resources to help decisionmakers improve the quality of peoples' lives."

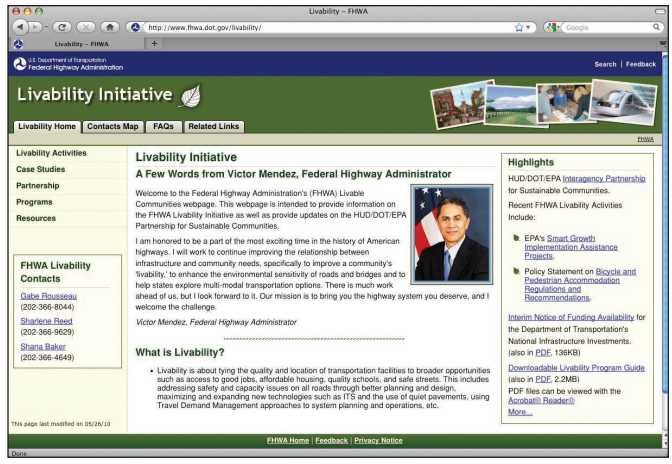
The Livability Movement

Though the livable community movement is not a new concept—it started more than a decade ago—it has picked up momentum recently because it is a priority of the current Administration to provide Americans with communities that are affordable and sustainable. In addition, more and more people want the convenience of being able to work, shop, learn, worship, and play without having to rely on motor vehicles.

The HUD/USDOT/EPA partnership is the pinnacle of the livability movement to date because it coordinates Federal policies, programs, and resources to help build more sustainable communities. The partnership has outlined six guiding principles of livability that it will use to coordinate Federal transportation, environmental protection, and housing investments at the respective agencies:

(1) Provide more transportation choices. (2) Promote equitable, affordable housing. (3) Enhance economic competitiveness. (4) Support existing communities. (5) Coordinate and leverage Federal policies and investment. (6) Value communities and neighborhoods.

Where possible, HUD, EPA, and USDOT are coordinating and integrating their programming and planning to identify



opportunities and remove barriers to building livable communities. The partnership also plans to provide a vision for sustainable growth; redefine housing affordability and make it transparent; redevelop underutilized community sites; develop livability measures and tools; and undertake joint research, data collection, and outreach.

Navigating the Web Site

The home page of the Livability Initiative Web site features a "Highlights" box with links to program updates and contact information for FHWA's livability experts. Users also can access livability contacts at the FHWA division offices by clicking on the "Contacts Map" tab.

The "Livability Activities" page lists regional and USDOT activities aimed at building awareness of livability issues. The "Programs" page summarizes FHWA programs that support livability and provides links to more information. Through the "Resources" section, users can access links to livability-related resources on the FHWA Web site, including information on planning, context sensitive solutions, and scenic and historic trails. The "Related Links" section provides connections to relevant sites operated by industry associations and nonprofit organizations.

One of the most important purposes of the site is information sharing. Site users can access a series of case studies compiled by the FHWA Office of Planning, Environment, and Realty that highlight real-world examples of highways that support livable communities in rural, urban, and suburban areas. For example, one case study highlights the city of Raleigh, NC's transportation network, which features a sustainable pattern that supports future land uses, minimizes vehicle miles traveled, and reduces greenhouse gas emissions.

"The overall objective is to build more livable communities nationwide," Rousseau says. "And the FHWA Livability Initiative Web site supports this objective by encouraging the exchange of ideas, issues, and programs."

Alicia Sindlinger is a contributing editor for PUBLIC ROADS.

NATIONAL HIGHWAY INSTITUTE

Training Update

by Amanda Moss

NHI Celebrates 40 Years of Service

When the National Highway Institute (NHI) first opened its doors in 1970, it was a small operation with a handful of employees who completed every course registration, every scheduling arrangement, and every certificate by hand. Understandably, the menu of courses was slim. Fast forward to 2010: NHI now regularly collaborates with partners across the transportation industry, both nationally and internationally, to offer a catalog that has grown to include hundreds of courses in 16 broad categories, including more than 50 distance learning courses that capitalize on the latest Web technologies.

"NHI's mission hasn't changed; the organization has just expanded in new directions to meet new challenges and opportunities," says NHI Training Director Rick Barnaby. NHI credits its continual growth over the past 40 years to two key elements: development of industry partnerships and adoption of new technologies.

Collaborating for Greater Success

NHI pursues strategic partnerships that enhance and attest to the quality of its training. For example, NHI is accredited by the International Association for Continuing Education and Training (IACET) as an authorized provider of continuing education units (CEUs). As an authorized provider, NHI can offer CEUs for its courses that qualify under the American National Standards Institute/IACET 1-2007 Standard, which "gives them validity as high-quality trainings," says NHI Instructor Liaison Carolyn Eberhard.

NHI also forges close relationships with internal FHWA groups, such as the Resource Center, and external groups, such as the American Society of Civil Engineers, State departments of transportation, and university transportation centers. Because of the global nature of transportation today, NHI also reaches beyond the Nation's borders to develop relationships with transportation professionals around the world. In fact, for more than 20 years, NHI and FHWA's Office of International Programs have collaborated to provide training resources, briefings on training processes, and Web-based training to dozens of countries that include Iraq, Korea, and Kuwait.

What's Popular Today

Highest Ranked Courses in 2009	Course #
Course with the Most Sessions	Safety Inspection of In-Service Bridges (FHWA-NHI-130055)
Most Popular Web-Based Training	TCCC Plan Reading (FHWA-NHI-134081)
Web-Conference Training with the Most Sessions	Fundamentals of Life Cycle Cost Analysis (FHWA-NHI-131113)
Highest Rated Course	Instructor Development Course (FHWA-NHI-420018A)

Then-Federal Highway Administrator Francis C. Turner (left) poses with Emmett H. Karrer, the first director of NHI, in September 1971.

"NHI recognizes that it is part of a bigger community" and that these partners have "the same vision of delivering knowledge," says Joe Toole, former associate administrator of FHWA's Office of Professional and Corporate Development (currently the associate administrator for safety). "NHI is stronger when aligned with these partners."

Advancing with Technology

In addition to expanded partnerships, NHI has evolved through the adoption and adaptation of new technologies. Beginning in the 1990s, NHI saw major operational changes due to computer technology. In 1992, NHI launched its Course Management and Training System, a computer program that stores information about NHI courses, including development milestones, attendance data, and contract funding levels.

In the late 1990s, NHI launched its Web site, providing customers quick and easy access to the entire catalog and an array of other training-related information. In addition, with the more recent launch of the NHI Store, members of the transportation community and the public can order copies of training materials online at www.nhi.fhwa.dot.gov/training/nhistore.aspx.

On the training delivery front, NHI launched its first Web-based training in 2003. Web-based training is a lower cost, self-study option that enables participants to learn at their own pace wherever they can access the Internet. Soon after, NHI launched Web-conference training, in which participants join live training online at a set time. These Web-based options give NHI the ability to reach more people, more efficiently.

Perhaps NHI's most notable accomplishment in its 40-year presence is the change it has inspired within the transportation community. "NHI's work has resulted in changes—the way people design bridges, the way people build safety into our roads, the way they involve the public in transportation decisions, and much more," says Toole. "All of these advancements have improved our Nation's roadways, and NHI has played a significant role in making that happen."

Amanda Moss is a contractor for NHI.

Communication Product Updates

Compiled by Zachary Ellis of FHWA's Office of Corporate Research, Technology, and Innovation Management

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

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

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703–605–6000
Toll-free number: 800–553–NTIS (6847)
Web site: www.ntis.gov

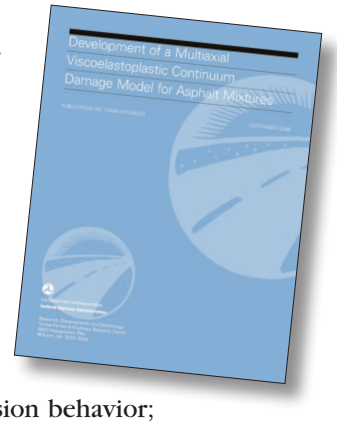
Requests for items available from the R&T Product Distribution Center should be addressed to:

R&T Product Distribution Center
Szanca Solutions/FHWA PDC
13710 Dunnings Highway
Claysburg, PA 16625
Telephone: 814–239–1160
Fax: 814–239–2156
Email: report.center@dot.gov

For more information on R&T communications products available from FHWA, visit FHWA's Web site at www.fhwa.dot.gov, the National Transportation Library's Web site at http://ntl.bts.gov, or the OneDOT information network at http://dotlibrary.dot.gov.

Development of a Multiaxial Viscoelastoplastic Continuum Damage Model for Asphalt Mixtures
Publication No. FHWA-HRT-08-073

Asphalt concrete pavement, one of the largest infrastructure components in the United States, is a complex system that involves multiple layers of different materials, various combinations of irregular traffic loading, and a variety of environmental conditions. With the goal of evaluating long-term pavement performance accurately, researchers have developed advanced models for asphalt concrete under complex loading conditions. This report highlights the development of the multiaxial viscoelastoplastic continuum damage model for asphalt concrete in both compression and tension, and documents the research conducted at North Carolina State University under contract to FHWA.



Over the past decade, researchers have developed uniaxial material models that can accurately capture various critical phenomena such as microcrack-induced damage that is critical in fatigue modeling, strain-rate temperature interdependence, and viscoplastic flow. The initial model focused on uniaxial tension behavior; however, accurately predicting the performance of an asphalt mixture in a pavement structure requires a multidimensional model. The multiaxial viscoelastoplastic continuum damage model combines elements of viscoelasticity, continuum damage mechanics, and viscoplasticity to model the material's behavior. Another factor critical to predicting the performance of the real pavement structures is incorporating the material model into a pavement model that considers the vehicle and climatic loads and the boundary conditions. Researchers developed the in-house finite element package for this purpose. According to the report's conclusions, the resulting predictions are reasonable and a reliable simulation of pavement response. Researchers are now applying these models within a performance specification for asphalt mixtures.

The report is available at www.fhwa.dot.gov/publications/research/infrastructure/pavements/08073/index.cfm. Printed copies also are available from the PDC.

Real-Time Pedestrian Detection: Layered Object Recognition System for Pedestrian Collision Sensing (Fact Sheet)
Publication No. FHWA-HRT-10-022

Current pedestrian detection technologies use fixed cameras pointing at predetermined zones, or vehicle-mounted monocular camera systems. To detect pedestrians more accurately and reduce pedestrian fatalities, a project sponsored by FHWA's Exploratory Advanced Research (EAR) Program moves beyond current systems and integrates two- and three-dimensional technology to provide cues for potential locations of pedestrians. This fact sheet discusses the current state of the technology, the project's layered processing framework, the major challenges to overcome, and future efforts.

This EAR project focuses on developing a real-time, in-vehicle, vision-only system to detect pedestrians and to determine potential collisions with high accuracy and minimal false alarms. Using multiobject classification, the system distinguishes seven classes of objects—the ground, pedestrians, vehicles, buildings, bushes, trees, and other tall vertical structures such as light poles. The layered pedestrian-detection algorithm can then recognize objects that are not pedestrians and eliminate them from analysis, gaining real-time performance speed in hazard identification.

The fact sheet is available at www.fhwa.dot.gov /advancedresearch/pubs/10022/index.cfm. Printed copies are available from the PDC.

Driving Automation Forward: Human Factors For Limited-Ability Autonomous Driving Systems (Fact Sheet) Publication No. FHWA-HRT-10-021

In May 2010, speaking to students and faculty at the Massachusetts Institute of Technology, Secretary of Transportation Ray LaHood underscored the need to enlist the country's best and brightest to help solve today's transportation challenges. Among those challenges are designing vehicles that emit zero greenhouse gases, engineering a revolution in green energy, and building cars that do not crash. On the latter point, FHWA's Human Factors for Limited-Ability Autonomous Driving Systems, an EAR project, aims to investigate driver engagement through the development of limited-ability autonomous driving systems. This fact sheet discusses a brief history of vehicle automation, knowledge gaps in working with human factors, automated driving challenges, and the future of automation.

The EAR project addresses a critical technology and knowledge gap that limits the near-term availability of vehicles that can control their own speeds and steering for substantial distances on public roads. One question is how to help drivers maintain adequate situational awareness so they are prepared to intervene when traffic conditions require. With this in mind, the EAR project will use smart adaptive cruise control, lane centering, and two next-generation driver-assistance technologies that automate longitudinal and lateral control. The study will involve human factor studies and experiments in simulators, on test tracks, and on public roads.

The fact sheet is available at www.fhwa.dot.gov /advancedresearch/pubs/10021/index.cfm. Printed copies are available from the PDC.

High Performance Concrete Bridge Deck Investigation (TechBrief) Publication No. FHWA-HRT-09-070

As part of an FHWA technology deployment initiative begun in 1993, State transportation departments started using high performance concrete (HPC) in their bridges. The program included the construction of demonstration bridges throughout the United States, which provided researchers with a large amount of data on the use of HPC. This report provides a summary of the performance of those bridges and information on the program's objective, background, investigation process, results, and recommendations.

FHWA compiled information from the demonstration bridges and used that data to develop recommendations on basic design parameters for HPC. The data included photographs and cross-sectional drawings of the bridges, as well as details about the materials and methods used in construction. The investigation demonstrated that HPC bridge decks can be constructed to perform well, and they exhibit relatively few cracks after multiple years of service.

The document is available at www.fhwa.dot.gov /publications/research/infrastructure/structures/09070 /index.cfm. Printed copies are available from the PDC.

Structural Behavior of a 2nd Generation UHPC Pi-Girder (TechBrief) Publication No. FHWA-HRT-09-069

Compared to more conventional concrete materials, ultra-high performance concrete (UHPC) exhibits superior properties such as exceptional durability, high compressive strength, usable tensile strength, and long-term stability. FHWA completed an experimental investigation focused on the structural behavior of a newly developed highway bridge girder cross section, the pi-girder. This girder was developed and optimized to exploit the advanced mechanical and durability properties of UHPC. The report provides information on the study's objective, the second-generation UHPC pi-girder, the test program, conclusions, initial pi-girder deployment, and recommendations for further development of the pi-girder.

The testing completed for this study focused on the structural performance of the girder's deck when subjected to simulated wheel loads. The design, fabrication, and testing of a second-generation UHPC pi-girder modular bridge component demonstrated the viability of the decked UHPC modular girders concept for use in conventional and accelerated bridge construction. The researchers found that the transverse flexural capacity of the girder is sufficient, and the capacity of the longitudinal joint exceeded that of the prefabricated deck.

The document is available at www.fhwa.dot.gov /publications/research/infrastructure/structures/09069 /index.cfm. Printed copies are available from the PDC.

Structural Behavior of a Prototype UHPC Pi-Girder (TechBrief) Publication No. FHWA-HRT-09-068

FHWA conducted an experimental investigation focused on the structural behavior of a newly developed highway bridge girder cross section, the pi-girder. This girder was developed and optimized to exploit the advanced mechanical and durability properties of UHPC. This report provides information on the study's objective, the UHPC prototype pi-girder, the test program, conclusions, and recommendations for further development of the pi-girder.

The research program included two phases. The first phase focused on the manufacture of four UHPC

pi-girders. Workers fabricated these 70-foot (21.3-meter)-long prestressed girders at a conventional production plant for precast bridge girders and then transported them to FHWA's Turner-Fairbank Highway Research Center. The second phase focused on the physical testing of the full-scale girders through the application of structural loads. The research demonstrated that the concept of decked UHPC modular girders for bridge construction is viable. The structural response of the girder prototype exceeds design requirements in terms of ultimate shear capacity and meets flexural design requirements with the inclusion of appropriate prestress force.

The document is available at www.fhwa.dot.gov/publications/research/infrastructure/structures/09068/index.cfm. Printed copies are available from the PDC.

Simulator Evaluation of Low-Cost Safety Improvements on Rural Two-Lane Undivided Roads: Nighttime Delineation for Curves and Traffic Calming for Small Towns (TechBrief) Publication No. FHWA-HRT-09-062

As part of an effort to support strategic highway safety plans, FHWA organized 26 States to participate in the Evaluations of Low-Cost Safety Improvements Pooled Fund Study. The purpose of this study is to estimate the safety effectiveness of several unproven, low-cost safety strategies identified in the National Cooperative Highway Research Program *Report 500* series.

This report, *Simulator Evaluation of Low-Cost Safety Improvements on Rural Two-Lane Undivided Roads: Nighttime Delineation for Curves and Traffic Calming for Small Towns*, examines low-cost visibility enhancements for navigating horizontal curves at night in rural areas. To help enhance the visibility of the curves, edgelines and post-mounted delineators (PMDs) were selected as the best alternatives for the simulator study. For curves, the researchers concluded that PMDs used with edgelines performed better in terms of slowing drivers down than pavement markings alone. The novel streaming PMDs solution—simulated reflectorized PMDs enhanced by light-emitting diode (LED) lamps that produce sequential streaming pattern of lights—offered the most dramatic potential benefit in terms of advanced curve detection.

Researchers also conducted tests to identify engineering measures to better manage speed on main roads through towns that are not suitable for traditional traffic calming techniques. The simulator study investigated the speed-calming effects of chicanes—artificial features that create extra turns in a roadway—located at the entrance to and exit from a town. In addition, bulbouts—curb extensions designed to slow drivers down—were evaluated at intersection locations in a town. For towns, the researchers concluded that chicanes slowed drivers the most, followed by parked cars on both sides of the road.

This document is available at www.fhwa.dot.gov/publications/research/safety/09062/index.cfm. Printed copies are available from the PDC.

Conferences/Special Events Calendar

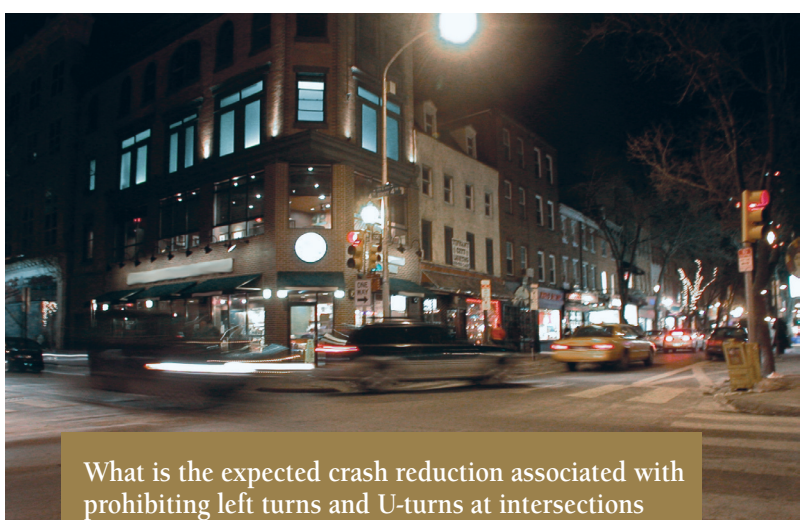
Date	Conference	Sponsors	Location	Contact
September 13–17, 2010	ProWalk/ProBike® 2010	National Center for Bicycling & Walking and the Federal Highway Administration's (FHWA) Safe Routes to School and Recreational Trails Programs	Chattanooga, TN	Sharon Roerty 973-378-3137 sharon@bikewalk.org www.bikewalk.org/2010conference
September 22–24, 2010	12th National Tools of the Trade Conference: Transportation Planning in Small and Medium Sized Communities	Transportation Research Board (TRB) Committee ADA 30, FHWA, Federal Transit Administration, and Virginia Department of Transportation (VDOT)	Williamsburg, VA	Kim Fisher 202-334-2968 KFisher@nas.edu www.trbtoolsofthetrade.org /conference.html
October 3–6, 2010	APTA Annual Meeting	American Public Transportation Association (APTA)	San Antonio, TX	Pamela Boswell 202-496-4803 pboswell@apta.com www.apta.com
October 18–19, 2010	Transportation Systems for Livable Communities Conference	TRB and the U.S. Department of Transportation's Research and Innovative Technology Administration	Washington, DC	Matthew Miller 202-334-2966 mamiller@nas.edu Tom Palmerlee 202-334-2966 tpalmerlee@nas.edu www.trb.org/conferences /livability2010.aspx
October 19–22, 2010	AMPO Annual Conference	Association of Metropolitan Planning Organizations (AMPO)	St. Louis, MO	Maria Staunton 202-296-7051, ext. 4 mstaunton@ampo.org www.ampo.org
October 24–27, 2010	Pavement Evaluation 2010	Virginia Tech Transportation Institute, VDOT, Virginia Transportation Research Council, FHWA, TRB, and Road Profiler Users' Group	Roanoke, VA	Gerardo Flintsch 540-231-9748 flintsch@vt.edu www.cpe.vt.edu/pavementevaluation
October 24–28, 2010	Green Concrete in the Steel City	American Concrete Institute	Pittsburgh, PA	Event Services 248-848-3795 conventions@concrete.org www.concrete.org
November 14–17, 2010	20th American Trails National Symposium	American Trails, FHWA's Recreational Trails Program, PlayCore™, Tennessee Department of Environment & Conservation, and Tennessee Greenways & Trails	Chattanooga, TN	Candace Mitchell 530-547-2060 candace@americantrails.org www.americantrails.org/2010

Broaden Your Safety Horizons

Find and compare alternative countermeasures using the Crash Modification Factors Clearinghouse.

How many run-off-the-road crashes can rumble strips likely prevent?

iStockphoto



What is the expected crash reduction associated with prohibiting left turns and U-turns at intersections compared with installing intersection lighting?

iStockphoto

What is the expected effectiveness of removing or relocating a fixed object in the clear zone compared with shielding the object with a guardrail?

iStockphoto

The Crash Modification Factors Clearinghouse can help transportation professionals answer some of the toughest questions. The clearinghouse is stocked with thousands of crash modification and reduction factors to serve as your one-stop shop for finding and comparing countermeasures.

- Learn more about crash modification factors.
- Identify potential countermeasures.
- Obtain the expected effectiveness of countermeasures.
- Compare alternative treatments.
- Locate training related to crash reduction factors.
- Access resources for cost-benefit analyses.

U.S. Department of Transportation
Federal Highway Administration

CMF
CRASH MODIFICATION FACTORS CLEARINGHOUSE

The Crash Modification Factors Clearinghouse is funded by the U.S. Department of Transportation Federal Highway Administration.

Visit the Crash Modification Factors Clearinghouse today!
www.CMFClearinghouse.org

U.S. Department
of Transportation
Federal Highway Administration
Attn: HRTM
1200 New Jersey Avenue, SE
Washington, DC 20590

Official Business
Penalty for Private Use $300

PERIODICALS
POSTAGE & FEES PAID
FEDERAL HIGHWAY ADMINISTRATION
ISSN NO. 033-3735
USPS NO. 516-690

FHWA-HRT-10-005
HRTM-03/07-10(5M200)E