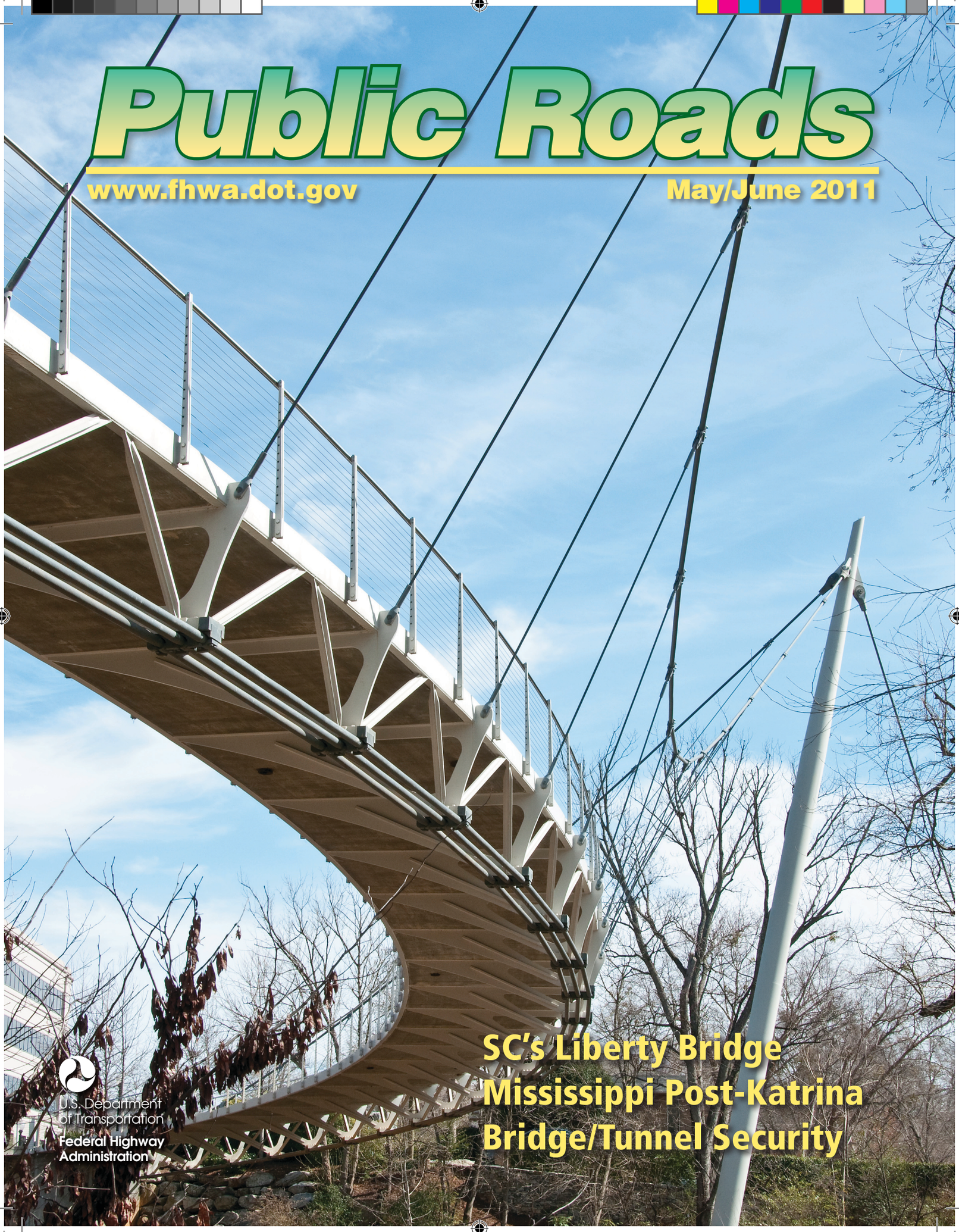
Public Roads

www.fhwa.dot.gov

May/June 2011



SC's Liberty Bridge
Mississippi Post-Katrina Bridge/Tunnel Security

U.S. Department of Transportation
Federal Highway Administration

Public Roads

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

May/June 2011 www.fhwa.dot.gov Vol. 74, No. 6

Articles

Page 2

Page 8

Page 28

Departments

Front cover—This dramatically curved pedestrian bridge in Greenville, SC, replaced a highway overpass and opened views of a waterfall in the heart of the city. The vision to demolish the old overpass and build the new pedestrian bridge originated with Greenville's residents, leadership, and transportation community. See "A City's Signature Centerpiece" on page 2 in this issue of PUBLIC ROADS. *Photo by Rob Thompson, SCDOT.*

Back cover—Strolling the lively downtown of Greenville, SC, and then ambling down landscaped terraces to cross this bridge is a pedestrian's ideal walk and a jogger's ideal run. The bridge helped rejuvenate the city and now serves as its new iconic image. *Photo by Rob Thompson, SCDOT.*

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*

Paula Magoulas, *Editor-in-Chief*

Paula Magoulas, *Publication Manager, Creative Director*

Norah Davis, *Editor*

John J. Sullivan IV, *Associate Editor*

Paula Magoulas, *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: 202–493–3398. Fax: 202–493–3475.
Email: paula.magoulas@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).

Guest Editorial

Using Information Investments Wisely

The investments that transportation agencies make in gathering and generating information are difficult to estimate but certainly considerable. Agencies collect and store data in multiple formats, ranging from files, tables, and documents to geographic information systems, images, and databases. The transportation community uses this information to increase understanding of the systems being analyzed, to inform decisionmakers and the public, and as a resource for future actions and performance measurement.

Despite all the information produced, finding relevant data for a task can be difficult. A synthesis of studies conducted by the International Data Corporation found that employees spend up to 35 percent of their time searching for information and that searchers are successful only 50 percent of the time or less, representing a loss of resources and time that could be spent more productively.

That's where librarians and library science add value, contributing expertise and tested methodologies to find and organize information. Professional librarians are skilled in research methods and knowledgeable about information classification systems and management techniques, enabling them to find information and resources quickly. They know how to phrase search terms and target sources that best fit information requests. They also have access to databases and information networks that enable them to procure resources in a least-cost manner.

The Washington State Department of Transportation hired a librarian specifically to manage information to support the Endangered Species Act consultation process for a corridor program. According to the department's planning manager, the librarian enabled the technical staff to respond more quickly and accurately to tasks requiring their specialized expertise, helping to expedite consultation on one project by more than 10 percent compared to the average consultation time. The conclusion: having a librarian on a megaproject is decidedly beneficial.

Improved access to information is not just about employing librarians and information professionals, but also about optimizing critical resources in a time of dwindling budgets. A review by Oracle found that 80 percent of an organization's information is unmanaged, increasing the likelihood that a significant amount will be difficult to find over time. In the digital age, information resources and products are commonly managed independently by functional groups within an organization or by information type (such as data, records, and manuals). Each group creates independent and task-specific classification systems. Few crosswalks exist to support searching and retrieval across these information silos. This inability to use information across an organization can impede achievement of strategic objectives.

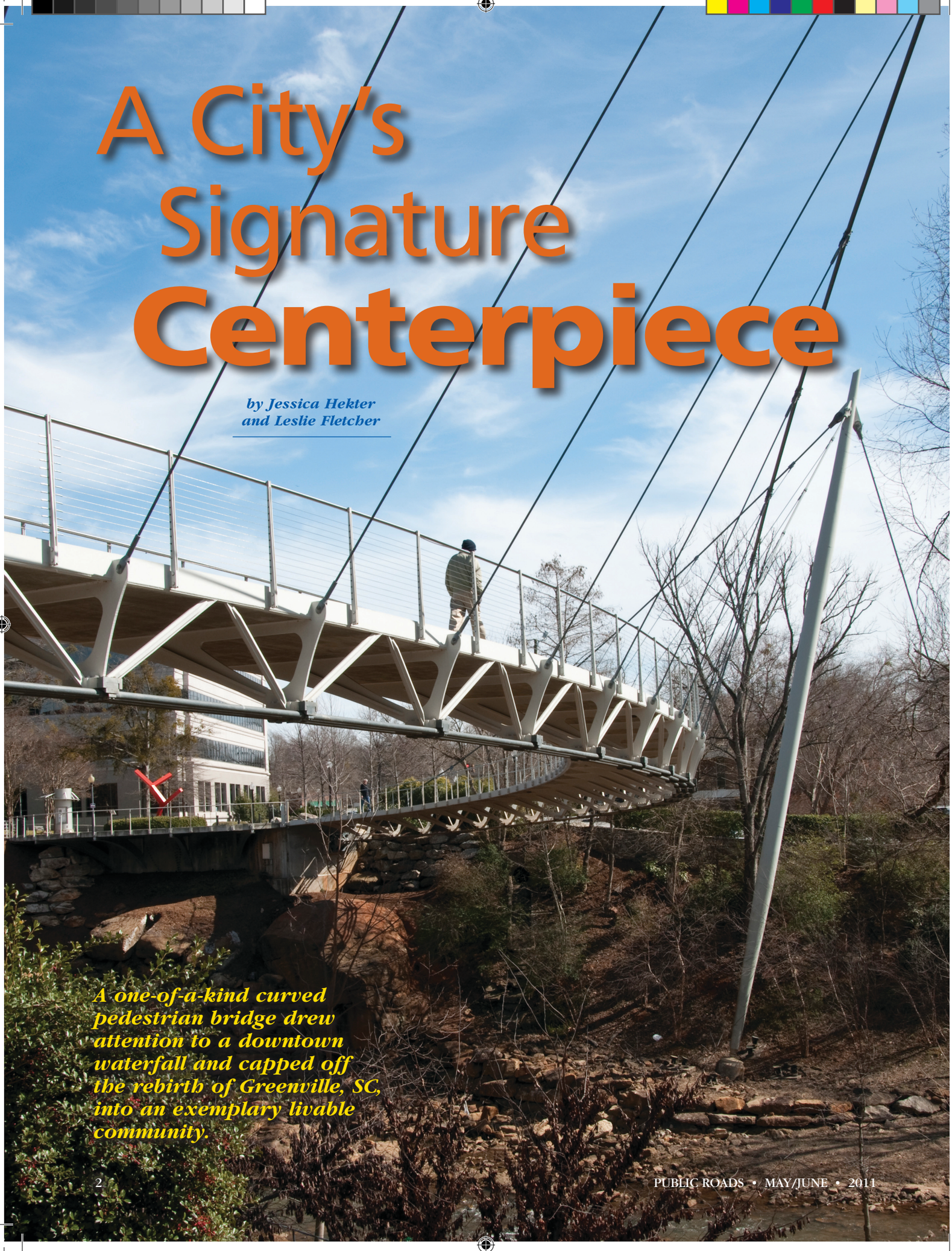
Efforts are underway to address these challenges, both regionally and nationally. Through development of transportation knowledge networks, transportation organizations are collaborating to improve information access, exchange, use, and preservation for their employees, partners, stakeholders, and the broader transportation community. For more information, see "Masters of Information" on page 28 in this issue of PUBLIC ROADS.

Transportation agencies have created a huge body of information. Wise stewardship of these assets will require improved management at the organizational level and support for emerging transportation knowledge networks. By increasing awareness and use of existing resources and promoting practices that improve the retrieval of information, the transportation community can build a strong information infrastructure that will support business needs far into the future. The investment in information made by the transportation community is simply too precious to squander.

Leni Oman
Director
Office of Research and Library Services
Washington State Department of Transportation

A City's Signature Centerpiece

by Jessica Hekter and Leslie Fletcher



A one-of-a-kind curved pedestrian bridge drew attention to a downtown waterfall and capped off the rebirth of Greenville, SC, into an exemplary livable community.

Simply put, downtown Greenville, SC, is a striking success story of how a community reinvented itself. A key component of the transformation was the replacement of a highway overpass with a dramatic pedestrian bridge. Here is the story of decay and rebirth and how the city accomplished its transformation to a sustainable community.

In the mid-20th century, Greenville's downtown along Reedy River experienced a severe decline. As was the case in many communities throughout the country, the downtown no longer was the city's major retail hub, and even though Greenville was thriving, Main Street was not participating in that growth. Walking down Main Street today, it is hard to believe that this tree-lined avenue, bustling with activity, was once mostly vacant.

The community had turned its back on the riverfront and its unusual waterfall, which cascades through a wooded valley in the heart of town. The water was polluted and the riverbanks littered with debris and trash. In 1960, a four-lane highway overpass, the Camperdown Way Bridge, was built across the waterfall, obstructing the view of the picturesque falls and creating a barrier to public access.

Clearly, action was needed. Faced with the slowly declining business district, Greenville leaders chose to partner with private developers to recreate the downtown in a model of sustainable redevelopment. In doing so, they created a livable city with a range of amenities rarely found in a community of 60,000 people. In short, Greenville set out to remake Main Street and create an atmosphere that would be conducive to entertainment and the arts, and attract offices, residential condominiums, and specialty retail businesses. Greenville's award-winning downtown affords a bricks-and-mortar testament to innovation.

"Greenville embraced the concept of redevelopment, making the city one of the early pioneers in reclaiming the prominence of its downtown," says Division Administrator Bob Lee of the Federal Highway Administration's (FHWA) South Carolina Division Office, "In the process, the city replaced a highway overpass with a landmark suspension bridge for pedestrians. Liberty Bridge curves in a sweeping arc just downstream from a waterfall, taking advantage of a unique natural feature."

Rosales + Partners

In this wooded valley in the heart of town, now called Falls Park, visitors stroll through multilevel terraces to the stunning Liberty Bridge just downstream from the waterfall (center of photo).

Creating the City's Image

While some cities work to maintain their distinct identity, Greenville had to work to uncover its uniqueness. In 1967, the Carolina Foothills Garden Club, with support from the city and Furman University, set out to bring the falls back to life. Furman University donated 6 acres (2.4 hectares) surrounding the falls, and in return the city agreed to create and maintain a park. The downtown took another turn for the better in the mid-1980s when the garden club and the city adopted a master plan for Falls Park, designed to restore the beauty of the area and provide a safe and welcoming public gathering spot.

Meanwhile, the Main Street streetscape project, completed in 1981, marked the first physical improvement. Through what would be considered a "road diet" today, the designers reduced Main Street from four lanes to two and widened the sidewalks for easier walking and outdoor dining.

Street trees were planted to further enhance the pedestrian experience, and parallel parking was replaced with free angled parking. The trees, which are now a signature element of Main Street, made it appealing to pedestrians and also screened some of the vacant and unattractive buildings. Further planning laid the groundwork for investments in plazas and public spaces and focused on highlighting one of the most spectacular features of Greenville's downtown—the Reedy River with its impressive series of natural waterfalls.

The Next Steps

With its new image in place, the city recognized the need for the public sector to step forward to provide the impetus for private investment. In 1982, the Greenville Commons/Hyatt Regency project created the city's first luxury convention hotel located directly on Main Street. Funded through a public-private partnership, it became a visible manifestation of Greenville's faith in the future of the downtown.

In 1990, The Peace Center for the Performing Arts, located on the banks of the Reedy River, opened as a result of a joint partnership of the city, county, and State governments. The arts complex not only stabilized a less-than-desirable part of town, but also triggered redevelopment on the south end of Main Street and linked downtown to its hidden assets—the river, park, and waterfall.

Around that time, the city established an ad hoc task force to review the impact of removing the Camperdown Bridge. In the

(Left) Arguably the most photographed landmark in Greenville, the pedestrian Liberty Bridge is the keystone of Falls Park and the downtown redevelopment. *Photo: Rob Thompson, SCDOT.*

These pedestrians are strolling Main Street during one of Greenville's frequent arts and crafts fairs. *Photo: Jacki Davies Meli.*

mid-1990s, the city and the Carolina Foothills Garden Club commissioned Washington, DC, landscape architect, Andrea Mains, to create a redevelopment plan for the park. Introducing the concept of transforming Falls Park into a regional attraction, her plan involved turning the passive green space into a major public garden. The plan presented the natural beauty of the falls and a world-class pedestrian bridge as critical components of the design. Support for the plan was confirmed in the 1999 *Reedy River Corridor Master Plan*.

Closing Down the Camperdown Bridge

At the time, the Camperdown Bridge was structurally adequate and in reasonably good condition but carried very little highway traffic (5,600 vehicles daily). Early on, the city approached FHWA and the South Carolina Department of Transportation (SCDOT) with a request to allow demolition of the federally funded structure. As the project champion, the city commissioned a transportation study evaluating the need for the bridge. After reviewing projected travel demand and the age of the structure, and taking Greenville's livability vision into consideration, FHWA agreed to support the project if the local government and metropolitan planning organization (MPO) could vote to support removal of the bridge. As with many metropolitan areas, the MPO provides a roundtable for transportation discussions and decisionmaking in the Greenville

Camperdown Bridge, shown here before its demolition, shaded the waterfall through most of the day so that many Greenville residents were unaware of their city's hidden asset. *Photo: City of Greenville.*

To reach the suspension bridge and view the scenic waterfall, these pedestrians walked down from Main Street through 20 acres (8 hectares) of terraced gardens and flowerbeds. *Photo: Rosales + Partners.*

area. Having been involved in a support role during the project development, the MPO passed a resolution supporting demolition.

Subsequently, in 2001, the Greenville City Council, working with SCDOT and FHWA's South Carolina Division Office, agreed to close a portion of the adjacent street to make way for removal of Camperdown Bridge as a prerequisite to the park redevelopment.

Funding and Designing Liberty Bridge

In 2003, Mayor Knox White announced a funding campaign for Falls Park. The fund was to provide a source of revenue for ongoing enhancements and programs, and the interest earnings were to be used for park expenditures above and beyond the city's normal park operating budget. At that time, individuals and corporations had already pledged $2 million to the endowment, with the most significant naming rights going to a new curved suspension bridge. The city announced that the bridge would be called the Liberty Bridge, in honor of The Liberty Corporation founder W. Frank Hipp and his children for their commitment and contributions to the Greenville community.

The city's hospitality tax, levied on prepared meals and beverages sold in Greenville, funded the $4.5 million structure. By South Carolina law, the hospitality tax must be used for tourism-related activities and improvements.

Bridge architect Miguel Rosales, AIA, president of Rosales + Partners of Boston, MA, designed the bridge; Schlaich Bergermann and Partner did the engineering; and Taylor & Murphy Construction Company, Inc., built the bridge. The park's different levels step down through gardens to provide various access points to the bridge. The architect designed the structure to create a dramatic aerial platform for viewing the falls and gardens. Local soil conditions and topography played an important role because the architect wanted the design to fit seamlessly into the landscape.

From conception to detailed construction documents took about 3 years, including an extensive review process by city officials and residents. Construction took about 14 months and was completed in 2004.

The New Bridge's Vital Statistics

Liberty Bridge is 345 feet (105 meters) long and 12 feet (3.7 meters) wide with an 8-inch (20-centimeter)-thick, concrete-reinforced deck supported by a single suspension cable. The deck's distinctive long sweeping curve has a radius of 214 feet (65

A clear span of 345 feet (105 meters) between the abutments makes the bridge appear to float above the landscape, a dramatic effect accentuated at night by specially designed lighting. *Photo: Rosales + Partners.*

meters) and is cantilevered toward the waterfall from the supporting cables on the outside of the curve to allow unobstructed views of the falls. The deck is a ramp that rises 12 feet (3.7 meters) or 3 percent from east to west as it crosses the river.

Three primary cable systems work with and against each other to support the bridge and hold its position in space. Underneath the deck are three 3-inch (80-millimeter)-diameter ring cables that support the deck and also place it into compression in the horizontal plane. Working against the ring cables in the horizontal direction, but with them in the vertical, are 1.18-inch (30-millimeter) hanger cables. The hanger cables are set from 35 degrees to 60 degrees from vertical and are supported by the catenary or main cable. The main cable is actually three separate 3.15-inch (80-millimeter) cables—two spanning from the abutment blocks to the steel mast and one spanning from mast to mast in the center of the span.

Two 90-foot (27-meter)-tall masts weigh more than 28 tons (25 metric tons) each and incline away from the bridge at a 15-degree angle. Two 3-inch (80-millimeter) backstay cables hold the masts in position. Steel piles and rock anchors, some 70 feet (21 meters) deep into bedrock, transfer the bridge loads to the ground at the abutments, mast, and backstay foundations. The architect concedes that the diameter or cross section of the steel towers could be a bit smaller, but in general he is satisfied with the end result.

The bridge is mostly steel, with smaller and more slender members than most bridges. The engineering firm conducted a detailed study of the characteristics and performance of the cables to find the best configuration and to balance aesthetics and functional considerations.

The elegant curve required extensive calculations and analysis to ensure balance of the forces between the cable above the deck and the three ring cables under the deck that connect to the steel truss. The stiff steel truss helps stabilize the structure during use. The bridge does vibrate and sway slightly, but not uncomfortably; in fact, it moves more when fewer people are using it. About 1,300 can stand on the bridge at a time safely, according to the architect. "We used high levels of safety standards well beyond the actual physical live load capacity that the bridge can accommodate," Rosales says. "All possible live and dead loads needed to be considered, because small vehicles such as bicycles also can use the bridge."

The bridge's soft blue lighting is integral to the experience of

Liberty Bridge Awards

- One of five finalists for the 2006 Outstanding Civil Engineering Achievement Award from the American Society of Civil Engineers
- 2005 Award for Excellence in Hot-Dip Galvanizing Recreation and Entertainment from American Galvanizers Association
- 2006 Pinnacle Award for Best Highway-Heavy Project from Carolinas Associated General Contractors
- 2005 Arthur G. Hayden Medal for outstanding achievement in bridge engineering demonstrating innovation in special use bridges
- 2005 Prize Bridge Award for special purpose bridges from The National Steel Bridge Alliance
- 2005 International Footbridge Award in the aesthetics category (medium span), awarded in Venice, Italy

crossing the bridge at night. "The light transforms the appearance of the concrete walking surface, making it appear much softer and more delicate," says Rosales.

The Bridge's Impact

"Although bridges with similar structural concepts have been built in Germany and Spain, the Liberty Bridge is distinct in its geometry," says Rosales. "There is nothing like it elsewhere in the United States."

The bridge serves as the park's focal point, overlooking Reedy River Falls where Richard Pearis, Greenville's first European settler, established his trading post around 1770. The beauty of the waterfalls and gardens is enhanced by the bridge's graceful lines and the appealing stonework used throughout the park.

Enthusiastic crowds gathered in downtown Greenville on September 10, 2004, to celebrate completion of the $13.4 million renovation of the park and landmark pedestrian bridge. "Falls Park and the beautiful Reedy River Falls have regained their rightful place of prominence in our city," said Mayor White at the dedication ceremony. "I invite everyone to visit the park, take a walk on the bridge, and enjoy this spot that is the birthplace of Greenville."

Falls Park and the Liberty Bridge did for South Main Street what the convention center and streetscaping did for North Main Street, accelerating development along the river. The park and bridge sparked a $65 million development, RiverPlace, completed in 2005 and marking the city's largest public-private partnership to date. Located on the banks of Reedy River, the development consists of condominiums, offices, retail shops, artist studios, restaurants, and a hotel. A garage is located beneath the building, and public walkways and plazas link RiverPlace to Falls Park. "RiverPlace is environmentally sensitive to the site and established a design standard for the community," says Nancy Whitworth, director of the city's Economic & Community Development Department.

Falls Park and Liberty Bridge serve as a major tourist destination and Greenville's signature postcard setting. The city estimates a minimum of 1 million visitors have enjoyed Falls Park since it opened, and potential private investment in the immediate area could reach 10 to 20 times the public investment.

"The success of Main Street and downtown Greenville is a result of 30 years of hard work and strong partnerships between the public and private sectors," says Whitworth. "Greenville has focused on creating a vibrant downtown that is authentic, sustainable, and most important, designed for people. Together, the city and community have been able to realize Greenville's potential and capitalize on its uniqueness."

Jessica Hekter is the manager of the planning, air quality, and right-of-way programs at FHWA's South Carolina Division. She holds a B.S. in community and regional planning from Iowa State University.

Leslie Fletcher is the communications manager for the city of Greenville. She holds a B.A. in English from Clemson University.

For more information, contact Jessica Hekter at 803-765-5458 or jessica.hekter@dot.gov or Leslie Fletcher at 864-467-4435 or lfetcher@greenvillesc.gov.

Reedy River Falls is now accessible to visitors and residents alike, making for a water experience that is unusual in the heart of a city. *Photo: Rosales + Partners.*

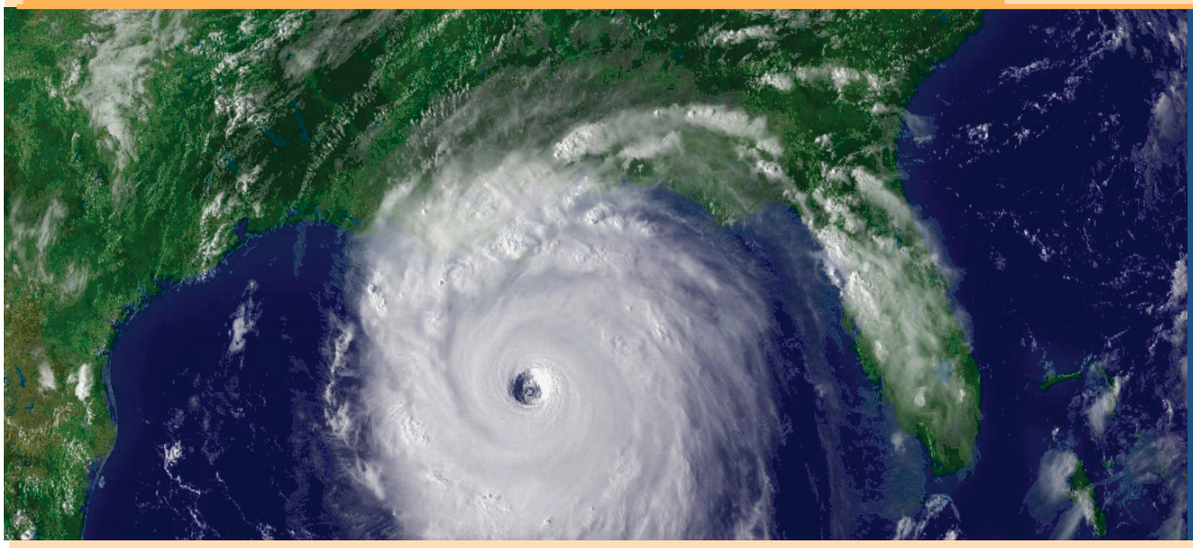
KATRINA'S AFTERMATH ARTICLE I

Mississippi's Recovery

by Donald Davis and Norah Davis

With two major bridges destroyed and $1 billion in infrastructure damages, restoring safety and mobility was both a challenge and an emotional journey for the division office.

"The destruction was horrendous—roadways and bridges destroyed, landmark buildings gone, boats and casino barges deposited throughout the area, and debris everywhere," recalls Federal Highway Administration (FHWA) Mississippi Division Administrator Andrew H. Hughes, speaking of the wreckage left by Hurricane Katrina.



(Above) In August 2005, Hurricane Katrina destroyed the U.S. 90 Saint Louis Bay bridge, shown here in a photograph taken by the FHWA Mississippi Division Office.

(Left) This satellite photograph shows Hurricane Katrina as it bore down on the coast. *Photo: National Oceanic and Atmospheric Administration.*

Like many other roads, this section of U.S. 90 in Biloxi buckled under the hurricane's storm surge.

The U.S. 90 Biloxi Bay bridge was destroyed, as shown graphically in this photograph.

Jeffrey A. Schmidt, the division office's field operations team leader, adds, "Seeing the total devastation the first time was unbelievable. Buildings were heaped on top of buildings; boats and trucks were overturned."

Hughes and Schmidt are referring to their first impressions during a reconnaissance tour of Mississippi's coastal counties 24 hours after Hurricane Katrina roared through the State on August 29, 2005. What they found were highways either destroyed or piled high with rubble. Most main roads had one makeshift lane open, permitting only emergency vehicles around damaged pavement. Hughes and Schmidt were permitted access to assess damage to the highway infrastructure, but even so the two FHWA officials frequently had to detour onto residential streets just to get through.

Their first destination on the coast was Interstate 10, a major transportation link that is heavily used by long-haul trucks. Several spans of the eastbound I–10 bridge over the Pascagoula River were heavily damaged, leaving the critical eastbound interstate route out of devastated New Orleans impassable. Nearby on U.S. 90, the Saint Louis Bay and Biloxi Bay bridges were totally destroyed.

But this is getting ahead of the story. What follows is a recounting of the Hurricane Katrina Emergency Relief Program efforts through the eyes of the FHWA Mississippi Division.

Weathering the Storm

Before the hurricane hit, as Katrina was still bearing down on the coast, Hughes had most of the division employees report to the Jackson office to prepare for the storm. The division office is about 140 miles (225 kilometers), as the crow flies, from the Mississippi coastal towns of Biloxi and Gulfport. In addition to battening down the hatches, the division leadership prepared the field staff for emergency relief work by reviewing FHWA's *Emergency Relief Manual*, assessing anticipated needs for damage inspection teams, and coordinating with the Mississippi Department of Transportation (MDOT).

The power at the division office went off around 10 a.m. Shortly after that, Hughes sent most of the staff home to ride out the storm. By the time he left 2 hours later, heavy rain was falling and sustained 90-mile (145-kilometer)-per-hour winds were battering Jackson. The eye of the storm traveled through Mississippi only 40 miles (64 kilometers) east of the division office.

This section of U.S. 90 along the coast in Harrison County was covered by sand and debris.

After the hurricane, millions of cubic yards of debris had to be cleared from secondary roads like this one in Harrison County.

This photograph shows another view of the destroyed Biloxi Bay bridge. Concrete from the old bridge was used to build artificial reefs in the Gulf.

"I drive a pickup truck, but there's a pretty high-level interchange I have to go through to get home," says Hughes. "For a while there, I thought I'd made a mistake and stayed too long at the office. It was pretty wild."

The Immediate Aftermath

The day after the storm, when Hughes returned to the office, he found one government vehicle damaged, the power out, and the telephone system down. With his landline out, his cell phone rang at 7 a.m. It was FHWA's then Acting Administrator J. Richard Capka and a team of his colleagues calling from FHWA headquarters in Washington, DC. They were asking for a status report. Hughes reported all division personnel were safe, but some of their personal property had sustained damage. Hughes also reported that the Mississippi coast had suffered extensive damage to the transportation infrastructure.

After that, Hughes and Schmidt headed for the coast, stopping first in Hattiesburg to meet with MDOT officials. "We have an excellent relationship with MDOT and worked together from day one," Schmidt says.

After that meeting, Hughes and Schmidt in company with MDOT officials continued down to the coast to the damaged I–10 bridge. A 600-foot (183-meter) section of the eastbound bridge had been hit by barges and severely damaged. Eastbound interstate traffic was detoured onto local roads. Clearly, the first order of business would be to get I–10 functioning again.

Next on the reconnaissance tour was working their way west on U.S. 90. The four-lane highway is a critical economic lifeline along the coast, connecting communities, hospitals, and the coast's two main industries: seafood and casinos. Many sections of the highway were covered with sand and debris; others were washed out by water from the storm surge. "Never in my life have I seen anything like it," says Hughes.

Emergency Relief Inspection Teams

Official Katrina statistics list 238 fatalities in Mississippi alone. The President quickly declared the entire State a disaster area, so the division office formed inspection teams to assess the infrastructure damage—the first step in obtaining Federal emergency relief program funds. Given the small number of employees in the division office compared to the magnitude of damage, Hughes called upon his counterparts in two nearby States for help. South Carolina sent three people, and Tennessee sent two to help form 13 inspection teams. (For more information on emergency relief funds, see www.fhwa.dot.gov/programadmin/erelief.cfm.)

The teams also included representatives from MDOT. At a joint kickoff meeting, FHWA and MDOT set up schedules for the inspections. In the coming days, the teams would end up inspecting the Federal-aid routes—thousands of miles—in the damaged counties.

Construction shown here underway was replacing damaged sections of the I–10 bridge over the Pascagoula River.

MDOT

This night shot shows the new aesthetically pleasing and pedestrian-friendly Biloxi Bay bridge. The bridge is higher to accommodate ships and to reduce the risk of future damage from storm surges.

Inspecting the coast was hazardous and complicated. There were no places to stay, so the teams had to drive to the coast from Jackson early in the morning, head back the same day, and then turn around and do it again the following day. This went on for 3 long weeks.

During the inspections, emergency centers were the only places to obtain food and water. There was no sanitation, and sewage was spilling out into the streets. At Gulfport, refrigerated containers of chicken and shrimp that had been waiting to be shipped overseas had washed up into the city. "The stench was unbearable. The damage assessments were quite an ordeal," recalls Hughes.

In the end, the supporting documentation for the emergency relief funds totaled thousands of pages. For each road, the inspection teams estimated the cubic yards of debris that would have to be removed, the guardrails damaged, pavement damage, structural damage, traffic signals down, and so on. The reconstruction of Mississippi's infrastructure ended up costing more than $1 billion. The emergency relief program provided 100 percent reimbursement for all eligible work, rather than the usual full reimbursement being limited to emergency work completed within 180 days.

The Rebuilding Gets Underway

To repair the damaged I–10 bridge, the State used accelerated procedures to award a $5.2 million contract within 1 week. The contractor demolished the damaged spans and reconstructed them, completing the work in 21 days. So within a month, thanks to accelerated construction, the bridge was totally operational and back to what it was before Katrina. At the same time, the contractor repaired another bridge on a spur that connects I–10 to Biloxi.

Concurrently, the State focused on restoring two lanes of traffic on U.S. 90 between Biloxi and Bay Saint Louis. According to *The Great Deluge*, a 2006 book about Katrina by Douglas Brinkley, during the storm U.S. 90 had "turned into a raging river." One of the casino barges sat in the middle of the four-lane highway.

"In order to restore the highway, it was obvious the top priority was to address how we were going to replace the bridges on 90," says Hughes. "The decision was made to utilize the design-build contracting mechanism for those two bridges. This was the first use of design-build in the State."

Throughout the process, FHWA headquarters provided crucial guidance on funding eligibility and help with hydraulic design and environmental clearance. In addition, headquarters helped with contract administration items, such as incentive/disincentive amounts, road user costs, and stipend allowance for the design-build projects.

The notice to proceed on the Saint Louis Bay bridge was issued on February 20, 2006, with a $266.8 million contract amount. A contract milestone called for completing half of the bridge and opening it to two-way traffic by May 16, 2007. The contractor was to receive a $5 million lump-sum bonus if that date was met. The contract also included a disincentive penalty of $100,000 per day if the contractor failed to meet that date. The contractor met the milestone date, earning the lump sum bonus. All remaining work included in that contract was completed February 15, 2008.

The notice to proceed for the Biloxi Bay bridge was issued on June 16, 2006, with a $338.6 million contract amount. This contract included

MDOT

Like the Saint Louis Bay bridge, the reconstructed Biloxi Bay bridge shown here has a high clearance because of the shipping channel.

U.S. 90 had to be totally reconstructed. Shown here is a rebuilt U.S. 90 intersection in Gulfport.

MDOT

This ferry provided service between Bay Saint Louis and Pass Christian during construction of the new bridge.

similar milestone and bonus provisions. The bridge was opened to two-way traffic on November 1, 2007, which was 12 days ahead of the milestone date to earn the bonus. All remaining work included in this contract was completed April 16, 2008.

At the height of the construction, two 10-hour shifts were used on both projects. Both bridges were standard construction with pile-supported, cast-in-place decks. The Saint Louis Bay bridge has four lanes plus a shared-use lane for pedestrians and bicyclists. The Biloxi bridge has six lanes plus a shared-use lane. The Saint Louis Bay bridge is 85 feet (26 meters) high to provide the necessary clearance above a shipping channel. The bridge is 2.1 miles (3.4 kilometers) long. Similarly, the Biloxi bridge is 95 feet (29 meters) high and 1.6 miles (2.6 kilometers) long. The bridges contain epoxy-coated rebar to withstand exposure to saltwater.

During construction of the Biloxi bridge, the detour used State highways and took only about 25 to 30 minutes. But with the Saint Louis Bay bridge, the detour on State highways and county roads took 45 minutes to 1 hour. As the project progressed, congestion began to increase, resulting in residents asking for ferry service to connect the cities of Bay Saint Louis and Pass Christian. Schmidt notes, "We had never procured a ferry service before."

But MDOT and FHWA met that challenge. The ferry was provided and carried about 25 cars at a time and operated 7 days a week, starting November 1, 2006, and continuing until two lanes of traffic opened on the bridge the following May. The Secretary of Transportation at the time, Mary E. Peters, came down from Washington for the maiden voyage, one of her first acts after taking office in October.

Hers was the third high-level visit. Previously, then Secretary of Transportation Norman Y. Mineta had visited twice—once right after the hurricane struck and then several months later to assess the progress of the recovery efforts in the Bay Saint Louis area.

In early 2006, after two lanes on U.S. 90 were opened to traffic, contracts were let to do temporary work to get all four lanes operational. After the new bridges were completed, U.S. 90 was totally rebuilt. The contracts for that work were awarded beginning in July 2007 and completed in March 2009, for a total of about $97.8 million.

As of mid-2011, Mississippi is very close to finishing all work associated with rebuilding the transportation infrastructure damaged by Hurricane Katrina.

The Wrap-Up

Instead of a ribbon-cutting ceremony, the two communities connected by the Saint Louis Bay bridge held a ribbon-tying celebration when the new structure opened to two-way traffic. A ribbon was stretched from each side—Bay Saint Louis and Pass Christian—and tied together in the middle of the bridge.

"That was one of the most emotional events I've ever attended," says Hughes. "People were crying for joy upon reconnecting the two

Another section of the reconstructed U.S. 90 roadway is shown here, this one in Biloxi.

MDOT

These happy celebrants are holding oversized red, white, and blue ribbons used for the ribbon-tying ceremony at the opening of the Saint Louis Bay bridge.

communities and reopening U.S. 90—the lifeline of the Mississippi coast."

Noting that Katrina was the most destructive hurricane to ever strike the United States, Hughes offers advice to other division offices facing major natural disasters: "React quickly, prepare yourself on the run, assemble the resources to do inspections, call in available resources if you need help, be prepared to do whatever it takes to get the job done, reach agreement with the State on the scope of work and the contracting mechanisms, and always maintain thorough and well-organized project records."

Schmidt adds, "We had a great team. MDOT and FHWA communicated exceptionally well, we made joint decisions, and that helped speed up the process: initial inspections, contracts, and design time. The major infrastructure was restored in record time."

This sentiment is echoed by then MDOT Executive Director Larry L. "Butch" Brown: "Although the recovery process was very complex and challenging, all parties, including the private sector, worked together and met the challenge. I am especially proud of the effort put forth to incorporate the principles of context sensitive solutions and livability in the reconstruction of U.S. 90."

Hughes concludes, "I've never lived through anything like this before—and hope to never experience it again."

MDOT

An exuberant billboard also celebrated the bridge's completion.

Donald Davis is the Mississippi Division's assistant division administrator. He has served with FHWA for 21 years with previous assignments in Texas, Florida, and Alabama following completion of FHWA's Highway Engineering Training Program. Davis is a graduate of The Florida State University with a B.S. in civil engineering.

Norah Davis is the editor of PUBLIC ROADS.

The authors gratefully acknowledge the assistance of Jeffrey A. Schmidt with editing and gathering data for this article.

For more information, contact Donald Davis at 601-965-4146 or donald.davis@dot.gov.

MDOT

Peace has returned to the Mississippi coast, as suggested in this sunset shot of the reconstructed Saint Louis Bay bridge.

by Ann H. Do, Kay Fitzpatrick, Susan T. Chrysler, Jim Shurbutt, William W. Hunter, and Shawn Turner

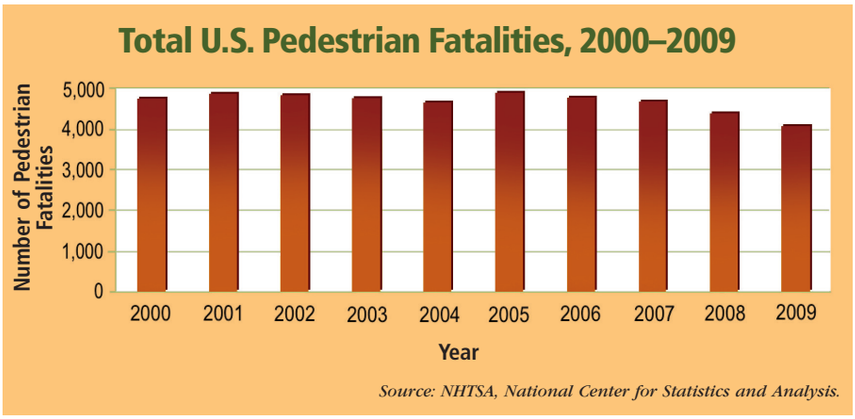
Safety Strategies Study

Findings from recent FHWA research point to effective medium- and low-cost engineering countermeasures for helping reduce fatalities and injuries among pedestrians and bicyclists.

(Above) In this rectangular rapid-flashing beacon (RRFB) installation on U.S. 92 in St. Petersburg, FL, the sign assemblies are located on both roadsides and in the median. The device is activated by pedestrians. *Photo: Michael Frederick, City of St. Petersburg, FL.*

In the United States, pedestrians killed in traffic crashes decreased 14 percent from 4,763 in 2000 to 4,092 in 2009. Bicyclist fatalities averaged 741 per year from 2004 to 2008 but decreased to 630 in 2009. Also in 2009, around 59,000 pedestrians and 51,000 bicyclists were injured. Although fatality and injury numbers have decreased slightly in recent years, pedestrians and bicyclists still face risks on the Nation's roadways.

To address this issue, the Federal Highway Administration (FHWA) continuously seeks to demonstrate and evaluate the effectiveness of existing and new engineering countermeasures that improve pedestrian and bicyclist safety. The aim of a recent FHWA project, Evaluation of Pedestrian and Bicycle Engineering Countermeasures, was to identify and quantify the effectiveness of selected medium- to low-cost strategies in improving safety and operations for pedestrians and bicyclists. The findings from this study can help State and local departments of transportation (DOTs) identify cost-effective techniques to implement on their highways and streets to help improve safety for pedestrians and bicyclists.



Identification of Countermeasures

The FHWA project focused on existing and emerging engineering countermeasures that have not yet been comprehensively evaluated. The process to identify potential countermeasures started with an extensive literature review of existing evaluations. The researchers also summarized requests sent to FHWA by public agencies for experimental pedestrian- and bicyclist-related traffic control devices not specifically addressed by the *Manual on Uniform Traffic Control Devices* (MUTCD).

Based on these evaluations, the researchers identified several candidate countermeasures, and then the FHWA staff selected a final list for the study. The countermeasures selected for evaluation were the rectangular rapid-flashing beacon (RRFB); the pedestrian hybrid beacon, formerly called High intensity Activated crossWalK (HAWK); shared lane markings for bicyclists (sharrows); and crosswalk markings as viewed by drivers.

The project also included the development of a report, *Pedestrian and Bicyclist Traffic Control Device Evaluation Methods* (FHWA-HRT-11-035) on the evaluation method for pedestrian and bicycle traffic control devices. The report's purpose is to educate practicing engineers, planners, and public works employees at the local, county, and State levels on how to conduct an evaluation of the effectiveness of traffic control devices.

Rectangular Rapid-Flashing Beacon

Past research studies have evaluated traffic control devices such as flashing yellow beacons intended to encourage drivers to yield to pedestrians at multilane crosswalks at uncontrolled locations with relatively high average daily traffic. Only devices that employ a red phase have consistently produced sustained high levels of yielding at these types of crosswalks. To address this problem, the rectangular rapid-flashing beacon flashes in an eye-catching sequence to draw drivers' attention to the sign and the need to yield to the waiting pedestrian. (See also "Evaluating Pedestrian Safety Countermeasures" in the March/April 2011 issue of PUBLIC ROADS.)

The RRFB is located roadside below pedestrian crosswalk signs and can be activated by a pedestrian either actively pushing a button or passively detected by sensors. Each side of a light-emitting diode (LED) flasher illuminates in a wig-wag sequence (left and then right).

During the baseline measurement phase, the researchers installed advance yield markings to reduce the risk of multiple-threat crashes, which occur when a driver stopping to let a pedestrian cross is too close to the crosswalk, masking the pedestrian from drivers in the adjacent lane. The advance yield markings were typically placed 30 feet (9 meters) in advance of the crosswalk unless a driveway or other issue was present, in which case they could be up to 50 feet (15 meters). The posted speed limit at the sites ranged between 30 and 40 miles per hour, mi/h (48 and 64 kilometers per hour, km/h).

The observers scored the percentage of drivers yielding and not yielding to pedestrians. Drivers were scored as yielding if they stopped or slowed and allowed the pedestrian to cross. Conversely, drivers were scored as not yielding if they passed in front of the pedestrian but would have been able to stop when the pedestrian arrived at the crosswalk.

The study took place at 22 sites in St. Petersburg, FL, Washington, DC, and Mundelein, IL, and the RRFBs produced an increase in yielding behavior at all of those locations. During the baseline period before the introduction of the RRFB, yielding for individual sites ranged between 0 percent and 26 percent. The average yielding for all of the sites was 4 percent before installation of the RRFBs. A major change to 78 percent from the baseline

Michael Frederick, City of St. Petersburg, FL

This photo shows a closeup shot of the RRFB installation on U.S. 92 in St. Petersburg, FL.

Mike Cynecki, City of Phoenix, AZ

In this pedestrian hybrid beacon treatment in Tucson, AZ, the beacon head is located both on the mast arm and on a roadside pole, and consists of two red lenses above a single yellow lens. The operation of the device is activated by the pedestrian.

condition occurred by day 7, a statistically significant increase (total of 82 percent) took place between day 7 and day 30, and similar yielding values occurred during the remaining observation days.

Data collected over a 2-year followup period at 18 of the sites confirm that the RRFBs continue to succeed at encouraging drivers to yield to pedestrians, even over the longer term. By the 2-year followup, the researchers determined that the introduction of the RRFB was associated with yielding that ranged between 72 and 96 percent. Therefore, the evidence for change was overwhelming and persisted for the duration of the study.

In July 2008 FHWA issued an interim approval for optional use of RRFBs as warning beacons to supplement standard pedestrian crossing or school crossing signs at crosswalks across uncontrolled approaches. (See http://mutcd.fhwa.dot.gov/resources/interim_approval/ia11/fhwamemo.htm.) Any jurisdiction interested in obtaining interim approval can submit a written request to FHWA, Director of the Office of Transportation Operations. Jurisdictions using RRFBs under the interim approval must agree to comply with the technical conditions detailed in the interim approval memo for all applicants. They also must agree to maintain an inventory of all locations where the devices are placed and to return the site to a condition that complies with the MUTCD if future incorporation of the RRFB into the MUTCD results in a different set of technical conditions, such as design, placement, etc.

Pedestrian Hybrid Beacon

The pedestrian hybrid beacon is located both on the roadside and on mast arms over the major approaches to an intersection. The head of the pedestrian hybrid beacon consists of two red lenses above a single yellow lens. It is normally "dark," but when activated by a pedestrian, it first displays a few seconds of flashing yellow followed by a steady yellow change interval, and then displays a steady red indication to drivers, which creates a gap for pedestrians to use to cross the major roadway. During the flashing pedestrian clearance interval, the pedestrian hybrid beacon changes to a wig-wag flashing red to allow drivers to proceed after stopping if the pedestrian has cleared the roadway, thereby reducing vehicle delays. Richard Nassi, while transportation administrator for the city of Tucson, AZ, created the pedestrian hybrid beacon. At the time of this study, the beacons were installed at more than 60 locations throughout the city.

The researchers conducted a before-and-after evaluation of the safety performance of the pedestrian hybrid beacon. Using an empirical Bayes method, their evaluations compared the crash prediction for the after period without the treatment to the observed crash frequency after installation of the treatment. To develop the datasets used in the evaluation, the researchers counted the crashes that occurred during the study period, typically 3 years before and 3 years after the installation.

The researchers created two crash datasets. The first dataset included crashes coded as occurring at the intersecting streets (identified by using street names). The second dataset was a subset of the first dataset and only included those crashes that had "yes" for the intersection-related code in the police report.

The crash categories examined in the study included total, severe, and pedestrian crashes. From the evaluation that considered data for 21 pedestrian hybrid beacon treatment sites and 102 unsignalized intersections (reference group), the researchers found the following changes in crashes after installation of the pedestrian hybrid beacons:

- A 29 percent reduction in total crashes (statistically significant)
- A 15 percent reduction in severe crashes (not statistically significant)
- A 69 percent reduction in pedestrian crashes (statistically significant)

FHWA added the pedestrian hybrid beacon to the MUTCD in the 2009 edition (see Chapter 4F). However, the pedestrian hybrid beacons included in the FHWA safety study differ from the material in the 2009 MUTCD in the following ways because the installations included in the FHWA study preceded the MUTCD guidance:

- Section 4F.02 of the MUTCD states, "When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then … the pedestrian hybrid beacon should be installed at least 100 feet [31 meters] from side streets or driveways that are

controlled by STOP or YIELD signs." All 21 pedestrian hybrid beacons included in this study are located either at a minor intersection (where the minor street is controlled by a STOP sign) or at a major driveway (where the driveway is controlled by a STOP sign).

- The 2009 MUTCD depicts an R10-23 sign with the symbolic red circle and a white background for the word "crosswalk" on the sign. The signs typically used at the studied pedestrian hybrid beacon locations do not have the symbolic red circle, and the crosswalk background is yellow.

The MUTCD includes guidelines for the installation of the pedestrian hybrid beacons for low-speed roadways where speeds are 35 mi/h (56 km/h) or less, and high-speed roadways where speeds are more than 35 mi/h (56 km/h).

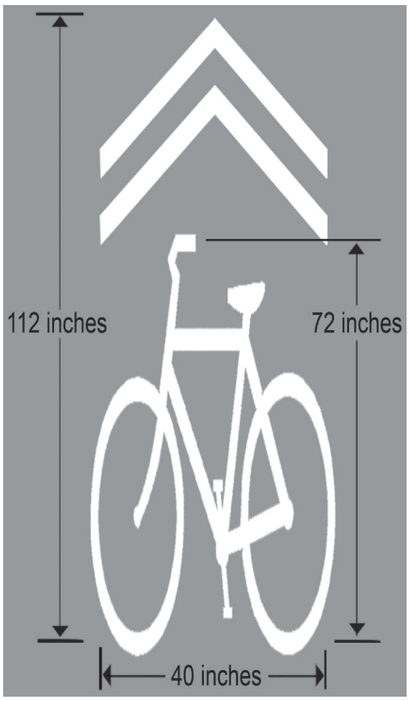
Shared Lane Markings

Shared lane markings, also known as "sharrows," convey the message that motorists and bicyclists must share the road. The arrow markings painted on the roadway indicate appropriate bicyclist positioning in the shared motor vehicle-bicycle lane. The purpose of the markings is to create improved conditions for bicyclists by clarifying where they are expected to ride and to notify motorists to expect bicyclists on the road.

The FHWA study aimed to evaluate the impact of shared lane pavement markings—specifically the so-called sharrow design—on operational and safety measures for bicyclists and motorists. The design incorporates two chevrons positioned over a bicycle outline and is placed on the pavement in the designated shared travel lane.

The researchers conducted experiments in three cities. In Cambridge, MA, local transportation officials were interested in experimenting with the placement of shared lane markings at a 10-foot (3-meter) spacing from the curb to prevent dooring, that is, when the occupant of a parked vehicle opens a door and hits an oncoming bicyclist. In Chapel Hill, NC, the researchers studied these markings placed on a busy five-lane corridor with wide outside lanes and no onstreet parking. In Seattle, WA, they evaluated shared lane markings placed in the center of the travel lane on the downhill portion of a busy street used by bicycle commuters. Prior to the treatment, a 5-foot (1.5-meter) bicycle lane was added to the uphill portion of the street in conjunction with shifting the center line.

Shared Lane Marking
2009 MUTCD



Source: MUTCD.

The study's researchers examined a variety of hypotheses such as: (1) The markings may help indicate a preferred travel path and thereby improve bicyclist positioning relative to parked motor vehicles when the cyclist is riding in shared lanes on a road that has onstreet parking, and (2) The markings may increase the distance of motor vehicles in the travel lane from parked motor vehicles or from the curb or pavement edge in the absence of bicyclists, thereby providing more operating space for bicyclists.

A number of variables related to the interaction and spacing of bicycles and motor vehicles showed positive effects. In Cambridge and Chapel Hill, more than 90 percent of bicyclists rode over the marking, indicating a high level of compliance with riding in the designated portion of the shared lane. In addition, motorists moved away from the marking to provide more operating space for bicyclists.

In Seattle, marking placement alone did not seem to result in an increase in the percentage of bicyclists using the lane. Bicyclists already were riding outside the dooring zone in the period before the treatment and stayed in this location in the after period. Shared lane markings had previously been installed 11 feet (3.3 meters) from the curb next to parked cars over a 2,000-foot (610-meter), four-lane section of Fremont Street leading into the section studied during the FHWA project. The researchers acknowledged the possibility that narrowing the travel lanes and adding the uphill bike lane had more effect on operations and spacing than the addition of shared lane markings.

Shared lane markings can be used in a variety of situations, and increased use should serve to boost motorists' awareness of bicycles, or the possibility of bicycles, in the traffic stream. Section 9C.07 of the MUTCD contains applicable requirements and guidance on design and placement of shared lane markings if they are used. As communities continue to use the markings, FHWA recommends similar trials in other locations and traffic settings, and then evaluation and reporting on those installations to gather more data for examination to help improve guidance for road agencies.

Crosswalk Markings

For the crosswalk marking study, the researchers investigated the relative daytime and nighttime visibility of three crosswalk marking patterns: bar pairs, continental, and transverse lines. The study collected information on the distance from the crosswalk at which 78 participant motorists verbally indicated visual recognition of the crosswalk under the different patterns. The participants were about evenly divided in gender between males and females and in age between younger than 55 years old and older than 55.

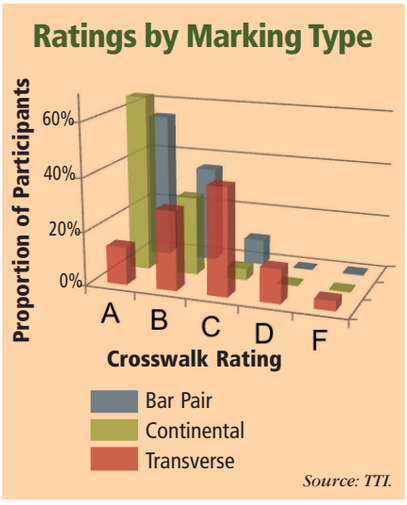
The FHWA researchers conducted the study in November 2009 using instrumented vehicles on a route along open roads on the campus of Texas A&M University in College Station, TX. The research team collected data during two periods: daytime (sunny and clear or partly cloudy) and nighttime (street lighting on). The tests used existing markings (six

Researchers at Texas A&M University studied the visibility of three types of crosswalk patterns installed on campus: (a) bar pairs, (b) continental markings, and (c) transverse markings. *Photos: Texas Transportation Institute (TTI).*

intersection and two midblock locations) and new markings installed for the study (nine midblock locations).

For the study sites, the findings indicate that the marking type (bar pair, continental, or transverse) was statistically significant. The detection distances to bar pairs and continental markings were statistically similar, and they were statistically longer than the detection distance to the transverse markings, both during the day and at night.

For the existing midblock locations, the drivers detected the continental markings at about twice the distance upstream as the transverse markings during daytime conditions.



This increase in distance translates to 8 seconds of increased awareness of the presence of the crossing at 30-mi/h (48-km/h) operating speeds.

The participants also rated the appearance of markings on a letter-grade scale of A to F. The researchers compared those subjective ratings of visibility for all the groups and variables identified in the preceding analysis. The ratings for bar pairs and continental were consistent over various comparison groups, with better ratings for bar pairs and continental markings than for transverse markings. These results mirrored the findings from the evaluation of detection distances. Overall, participants preferred the continental and bar pairs markings over the transverse markings.

The research team is working with the National Committee on Uniform Traffic Control Devices to develop recommendations for incorporating the findings from the study into the MUTCD.

Evaluation Methods Report

The report on evaluation methods developed as part of the FHWA project offers information to traffic engineering practitioners on how to conduct an evaluation of traffic control devices for roadways used by pedestrians and bicyclists. The report is designed for use by practitioners such as employees of State DOTs, plus county and city engineers and planners.

The first step of any evaluation is to clearly formulate the research question by identifying the motorist, pedestrian, or bicyclist behavior that poses a safety or operations problem. Practitioners then identify candidate traffic control devices and other countermeasures as potential solutions to that problem.

Evaluation methods described in the guide include user surveys or interviews, visibility studies, driving performance studies, observational traffic studies, and crash analyses. The selection of the appropriate evaluation method involves weighing cost, time, research aims, available research equipment, and staff. The evaluations conducted in the FHWA study exemplify several of the study approaches described in the evaluation methods report and can serve as models for studies that use crash analysis (pedestrian hybrid

beacons), traffic observations (RRFB and shared lane markings), and human factors (driver decisions regarding visibility of crosswalk markings).

Summary of Findings

FHWA's Pedestrian & Bicycle Safety Research Program's overall goal is to increase pedestrian and bicycle safety and mobility. From researching safer crosswalks, sidewalks, and pedestrian technologies to educational and safety programs, the program strives to make it safer and easier for pedestrians, bicyclists, and drivers to share roadways today and in the future. Under that program, this project focused on existing and emerging engineering countermeasures that have not yet been comprehensively evaluated in terms of effectiveness.

"These techniques, coupled with the critically necessary driver and pedestrian alertness, will assist the transportation profession in providing safer environments for the pedestrian and cycling community," says Nassi, who is currently traffic engineer for the Regional Transportation Authority, Pima Association of Governments.

The results of this study will be incorporated into the second versions of FHWA's online guides, Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE) and Bicycle Countermeasure Selection System (BIKESAFE). PEDSAFE and BIKESAFE were published in 2004 and 2005 respectively, and each provides general guidance on safety improvement, as well as a systematic approach to countermeasure selection. PEDSAFE Version 2 and BIKESAFE Version 2 are expected to be released in 2013.

Additional Information

Topics	Publications
RRFB	Shurbutt, J. and Van Houten, R. (2010). *Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks*, FHWA-HRT-10-043, Washington, DC. www.fhwa.dot.gov/publications/research/safety/pedbike/10043/10043.pdf
	Shurbutt, J. and Van Houten, R. (2010). TechBrief: "Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks," FHWA-HRT-10-046, Washington, DC. www.fhwa.dot.gov/publications/research/safety/pedbike/10046/10046.pdf
Pedestrian Hybrid Beacons	Fitzpatrick, K. and Park, E. S. (2010). *Safety Effectiveness of the HAWK Pedestrian Crossing Treatment*, FHWA-HRT-10-042, Washington, DC. www.fhwa.dot.gov/publications/research/safety/10042/10042.pdf
	Fitzpatrick, K. and Park, E. S. (2010). TechBrief: "Safety Effectiveness of the HAWK Pedestrian Crossing Treatment," FHWA-HRT-10-045, Washington, DC. www.fhwa.dot.gov/publications/research/safety/10045/10045.pdf
Shared Lane Markings	Hunter, W. W., Thomas, L., Srinivasan, R., and Martell, C. A. (2010). *Evaluation of Shared Lane Markings*, FHWA-HRT-10-041, Washington, DC. www.fhwa.dot.gov/publications/research/safety/pedbike/10041/10041.pdf
	Hunter, W. W., Thomas, L., Srinivasan, R., and Martell, C. A. (2010). TechBrief: "Evaluation of Shared Lane Markings," FHWA-HRT-10-044, Washington, DC. www.fhwa.dot.gov/publications/research/safety/pedbike/10044/10044.pdf
Crosswalk Marking	Fitzpatrick, K., Chrysler, S. T., Iragavarapu, V., and Park, E. S. (2010). *Crosswalk Marking Field Visibility Study*, FHWA-HRT-10-068, Washington, DC. www.fhwa.dot.gov/publications/research/safety/pedbike/10068/10068.pdf
	Fitzpatrick, K., Chrysler, S. T., Iragavarapu, V., and Park, E. S. (2010). TechBrief: "Crosswalk Marking Field Visibility Study," FHWA-HRT-10-067, Washington, DC. www.fhwa.dot.gov/publications/research/safety/pedbike/10067/10067.pdf
Evaluation Methods Report	Chrysler, S. T., Fitzpatrick, K., Brewer, M. A., and M. Cynecki. (2011). *Pedestrian and Bicyclist Traffic Control Device Evaluation Methods*, FHWA-HRT-11-035, Washington, DC. www.fhwa.dot.gov/publications/research/safety/pedbike/11035/11035.pdf
Summary Report	Fitzpatrick, K., Chrysler, S. T., Van Houten, R., Hunter, W. W., and Turner, S. (2011). *Evaluation of Pedestrian and Bicycle Engineering Countermeasures: Rectangular Rapid-Flashing Beacon, HAWK, Sharrow, Crosswalk Markings, and the Development of an Evaluation Methods Report*, FHWA-HRT-11-039, Washington, DC. www.fhwa.dot.gov/publications/research/safety/pedbike/11039/11039.pdf

Ann H. Do is a research highway engineer at FHWA's Turner-Fairbank Highway Research Center in McLean, VA, where she has managed the Pedestrian & Bicycle Safety Research Program since 2001. She joined FHWA in 1990 as a highway design engineer with the Eastern Federal Lands Highway Division. Do specializes in research related to safety effectiveness evaluations, pedestrians, bicyclists, human factors engineering, and geometric design. She has a B.S. in civil engineering from Virginia Tech.

Kay Fitzpatrick is a senior research engineer with the Texas Transportation Institute (TTI). Her research areas include pedestrians, geometric design, and roadway safety. She has a B.S. and M.S. in civil engineering from Texas A&M University and a Ph.D. from The Pennsylvania State University (Penn State).

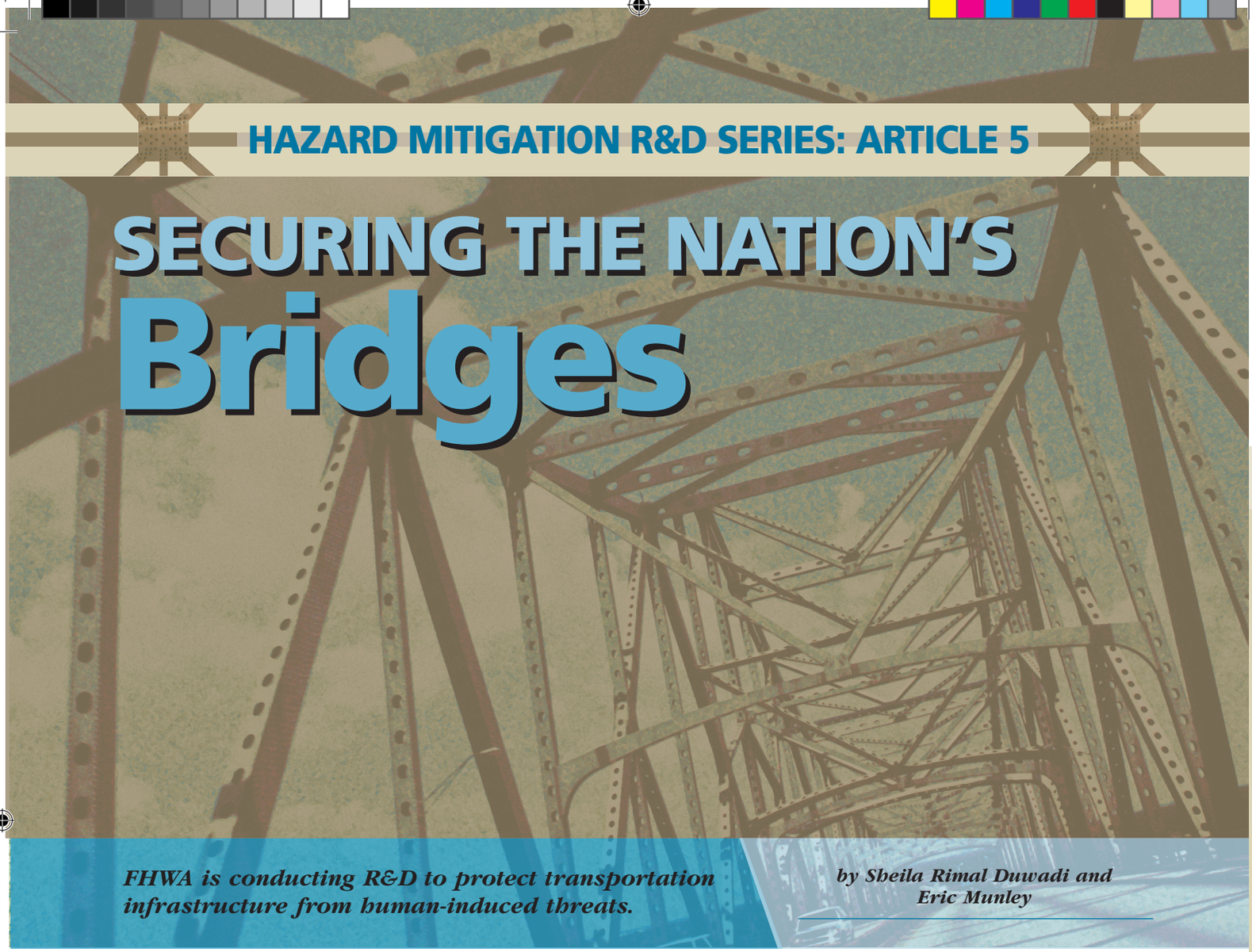
Susan T. Chrysler is a senior research scientist in the TTI Center for Transportation Safety and manager of the Human Factors program. Chrysler received her Ph.D. and B.A. in psychology from the University of Minnesota.

Jim Shurbutt earned his Ph.D. in applied behavior analysis from Western Michigan University while conducting this research.

William W. Hunter is a senior research scientist at The University of North Carolina's Highway Safety Research Center. He has an M.C.E. in transportation engineering from North Carolina State University.

Shawn Turner is a senior research engineer with TTI with research interest in pedestrian and bicyclist safety, traffic monitoring, and traffic data quality. He has a B.S. and M.S. in civil engineering from Penn State and Texas A&M University.

For more information, contact Ann Do at 202-493-3319 or ann.do@dot.gov, or Kay Fitzpatrick at 979-845-7321 or k-fitzpatrick@tamu.edu.



HAZARD MITIGATION R&D SERIES: ARTICLE 5

SECURING THE NATION'S Bridges

FHWA is conducting R&D to protect transportation infrastructure from human-induced threats.

by Sheila Rimal Duwadi and Eric Munley

Securing the Nation's critical infrastructure, including bridges and tunnels, emerged as a major issue after the terrorist attacks on September 11, 2001. Shortly thereafter, President George W. Bush began issuing a series of directives pertaining to homeland security. In December 2003, "Homeland Security Presidential Directive (HSPD) 7: Critical Infrastructure Identification, Prioritization, and Protection" established a national policy for Federal agencies to identify and prioritize critical infrastructure and to protect it from terrorist attacks. HSPD 7 listed the transportation system as a critical infrastructure sector and a lifeline essential to the Nation's mobility and economy. Further, HSPD 7 states that "the [U.S.] Department of Transportation and the Department [of Homeland Security] will collaborate on all matters relating to transportation security and transportation infrastructure protection."

The highway network provides for the continued movement of people and goods. Bridges and tunnels are crucial links in the system, and therefore their protection is an essential component of any security plan.

As noted in the National Bridge Inventory, the United States is home to approximately 600,000 bridges on public roads. Before September 11, these structures, like many other public properties, generally were not registered on security watch lists. However, after September 11, the Federal Highway Administration (FHWA), State departments of transportation (DOTs), and other bridge owners began to look closely at the vulnerabilities of the public properties they share responsibility for protecting.

FHWA, over the years, has invested extensive research dollars into providing safer highway infrastructure to protect against earthquakes, floods, hurricanes, traffic and construction incidents, and structural collapses. In many cases, FHWA started these hazard-related R&D programs in response to specific events. For example, the collapse of the Tacoma Narrows Bridge in 1940, caused by wind-induced oscillation, led FHWA's predecessor, the Bureau of Public Roads, to initiate a Federal program of research on bridge aerodynamics. But terrorism presents a unique challenge in that, to date, no bridges in the United States have been attacked by terrorists. However, authorities have apprehended individuals with ties

to known terrorist groups scouting and reporting on major bridges, offering further reason for FHWA to take proactive steps to improve security.

Although there are only a handful of different bridge types, each structure is designed to fit its specific location and circumstances. That means each has its own distinct vulnerabilities, depending on the design type, location, and materials used to construct it. Understanding these vulnerabilities is key to finding workable solutions for protection. Why a structure might fail depends on the structure type and the nature of the forces it must resist. Fire, blast, earthquake, flooding or scour, wind events, impact loadings, fatigue, fracture, and corrosion each represent a situation or event that could cause a bridge to fail. Unfortunately, there is no singular solution to make a structure immune to all conditions.

For natural hazards, such as earthquakes and hurricanes, scientists have identified regions of the country with statistically higher probabilities for exposure and determined where to concentrate mitigation efforts. But for human-induced hazards, the question is where to start? Should efforts be concentrated on individual landmark structures or structures on major economic corridors? Should the focus be on older structures or on developing new designs for bridges that have yet to be built? Transportation and security agencies further do not want counterterrorism strategies publicized, therefore development

Hazard Series Recap

The importance of reducing disasters through science and technology is recognized at the highest levels of the Federal Government. The White House National Science and Technology Council's Subcommittee on Disaster Reduction identified six "Grand Challenges" that if carried out will significantly reduce the likelihood that hazard events will turn into disaster events. In recent issues of PUBLIC ROADS, the Hazard Mitigation R&D Series has looked at transportation hazards from a number of perspectives and explored how R&D efforts at FHWA and beyond are responding to these challenges.

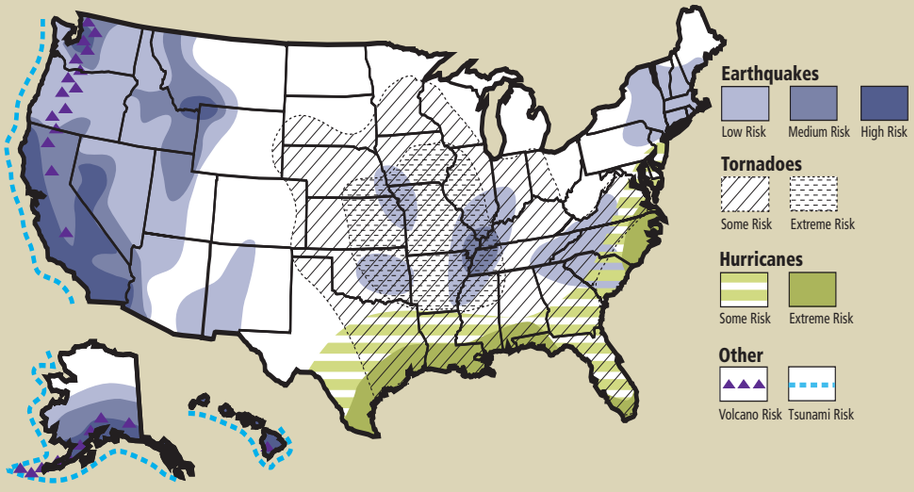
The first article, "Taking a Key Role in Reducing Disaster Risks" (PUBLIC ROADS, May/June 2010), examined FHWA's role in supporting the Grand Challenges through R&D to develop measures to prevent extreme events from disabling infrastructure. The article covered the types of extreme events and their impacts on transportation infrastructure, the role of highways in reducing fatalities and economic damages, and FHWA's role in finding solutions.

Subsequent articles highlighted in greater depth the variety of R&D activities underway in each hazard area. "Scour, Flooding, and Inundation" (PUBLIC ROADS, July/August 2010) introduced FHWA's advanced and applied hydraulics R&D program, which addresses the impact of waterborne hazards. The article surveyed past activities that have helped the bridge community cut costs and prevent new failures. The authors also shared ongoing research aimed at understanding hydrodynamic issues and providing improved aids to help bridge designers create more robust foundations. They also described efforts to advance the state of the art through high-risk, high-payoff research.

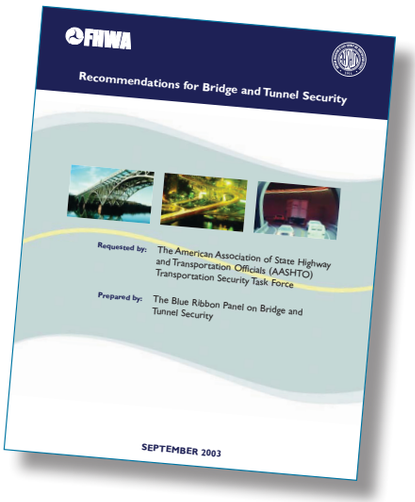
The third article, "Earthquake!" (PUBLIC ROADS, September/October 2010), covered FHWA's seismic research program and explored efforts to reduce risks from earthquakes. Research conducted by FHWA and its partners has changed how bridges are designed to withstand these events. The article discussed the design changes over the years and highlighted key products that have influenced how designers build for seismicity. The FHWA seismic retrofit and design manuals continue to provide guidance, while the Risks from Earthquake DAmage to Roadway Systems (REDARS) software serves as a decisionmaking tool to help bridge owners plan for and develop strategies to handle earthquake events.

Article four on "Winds, Windstorms, and Hurricanes" (PUBLIC ROADS, January/February 2011) presented FHWA's efforts to address vibrations and prevent structural failure due to heavy winds. Aerodynamics research to address wind-induced vibration is especially an issue for long-span bridges, a style that is growing in popularity as new technologies enable designers to build longer spans with slender components and cable-supported structures. Wind-induced vibrations also are a concern with signposts, another area in which the trend is to build longer spans and larger posts and arms, making connection details critical. The article discusses past, present, and future research and the products implemented to mitigate this hazard through work at TFHRC.

The present article—the last in the series—focuses on FHWA's bridge and tunnel security R&D and the agency's efforts to secure highway infrastructure from human-induced hazards.



This map shows regions of the United States that are susceptible to various types of disasters, such as earthquakes, tornadoes, and hurricanes. *Source: Recreated based on a presentation by the American Society of Civil Engineers' Committee on Critical Infrastructure.*



The Blue Ribbon Panel's report on bridge and tunnel security.

and deployment are seldom discussed openly, making sharing of information another challenge.

If economic disruption is a terrorist goal, highway corridors that move goods and services through rural parts of the country could be potential targets as well, especially those with major bridges in areas with few practical detours. But is it reasonable to expect that every bridge and tunnel—all 600,000 of them—should be designed or retrofitted on the chance that such an event might occur there? The easy answer would be "yes," if this were a small physical problem. However, bridge and tunnel protection is anything but.

For researchers at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA, in late 2001, any debate about bridge location and criticality quickly gave way to the physical problem of protecting bridge components. What *are* the best ways to protect them? It turns out that the means to secure bridges and tunnels against this type of threat still needs to be developed and refined. Through TFHRC, FHWA is doing just that.

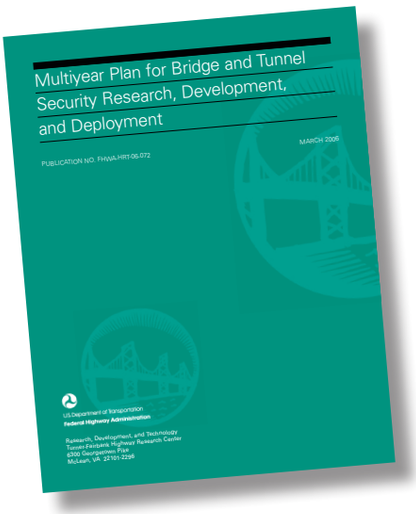
Interagency Collaboration

Responding to the security threat required collaboration among numerous public agencies, universities, and consultants. In the research and development (R&D) arena, partners including FHWA, State DOTs, and toll bridge authorities worked together to identify issues. Together, these agencies brought expertise in bridge design, construction, and operation, and an understanding of the many issues involved in the highway transportation field.

However, these agencies quickly discovered that the civilian highway community had little experience actually designing transportation infrastructure for this level of physical security and reached out to the military. Shortly thereafter an interagency collaboration started with the U.S. Army Corps of Engineers (USACE). With its extensive expertise developed during past and current military operations, USACE provided critical background on blast effects and other means of destruction and ways to protect structures against them.

Today, the U.S. Department of Homeland Security (DHS) plays a critical role in this collaboration, stemming from its primary responsibility for ensuring the Nation's safety and security. In addition, the Transportation Research Board (TRB), through its cooperative research programs, had been addressing security issues prior to 9/11 and substantially expanded its effort after. FHWA has continued to work with TRB in this effort.

In the end, transportation infrastructure owners will be the ones responsible for implementing any research recommendations or products developed, so R&D is being closely coordinated through owner agencies and through various American Association of State Highway and Transportation Officials (AASHTO) committees.



FHWA's *Multiyear Plan for Bridge and Tunnel Security Research, Development, and Deployment* outlines the agency's approach to addressing the need for securing transportation infrastructure.

Post-9/11 R&D Begins

Shortly after 2001, FHWA, in collaboration with AASHTO and TRB, convened a blue ribbon panel of bridge and structures experts representing Federal and State agencies and the consulting and academic communities. The panel met three times in late 2002 and early 2003 to develop strategies and practices for deterring, disrupting, and mitigating potential attacks, and reduce the vulnerability of bridges and tunnels. This collaboration resulted in the report *Recommendations for Bridge and Tunnel Security* (FHWA-IF-03-036), released in September 2003, which recommends policies and actions to "reduce the probability of catastrophic structural damage that could result in substantial human casualties, economic losses, and socio-political damage."

Meanwhile, in 2002, FHWA conducted a needs assessment with extensive outreach to solicit information on technology gaps from bridge owners, national laboratories, academia, consultants, and associations. This effort generated a list of research needs.

Then, in 2004, FHWA convened an R&D security workshop at TFHRC to augment the statements of research needs and broaden the basis for understanding the issues involved in developing a focused R&D program. Using the information gathered from these activities, FHWA identified the following major focus areas for R&D:

- Risk and vulnerability assessment
- Prevention, detection, and surveillance
- System analysis and design
- Material performance
- Rapid repair and restoration
- Postevent assessment
- Evaluation and training

In 2006, FHWA released its *Multiyear Plan for Bridge and Tunnel Security Research, Development, and Deployment* (FHWA-HRT-06-072). The plan called for, first, developing means and methodologies to prevent an incident from occurring;

second, protecting inhabitants and the structure if an event were to occur; third, having adequate resources to conduct a postevent assessment; and fourth, providing for repair and restoration of the structure in the most efficient manner possible.

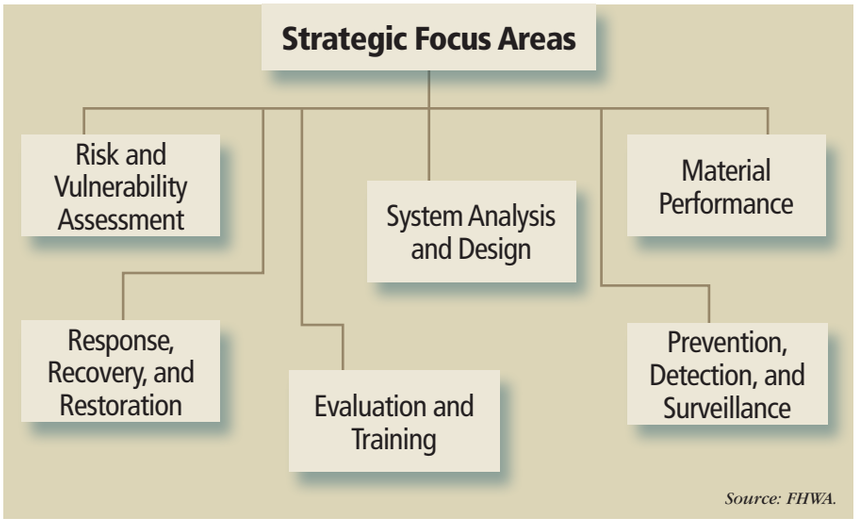
Looking ahead, more effective detection, surveillance, and warning systems would help mitigate incidents. Improved designs and effective uses of new materials could help protect structures and ensure that unpreventable damage does not result in complete failure, which could cause major disruption to the economy and possibly numerous lives lost. After an attack, transportation agencies would need technologies, equipment, and guidelines to determine the extent of damage and the residual strength remaining in the structure. The strategic research program developed calls for innovations in protective hardware, structural systems, and rapid construction and reconstruction. These systems and practices, when integrated into existing standards, could not only counter the effects of terrorist attacks but also might offer additional protective benefits relevant to other hazards, including earthquakes, scour, wind, overloads, or collisions.

Field Evaluations Refine Threat Discussions

In addition, soon after the September 11 attacks, FHWA started conducting onsite assessments of potential targets, including bridges and tunnels. In collaboration with USACE, FHWA began evaluating these structures around the country for their ability to resist attack. In 2003, FHWA's engineering assessment teams, along with engineers and inspectors from USACE, State and city DOTs, police and fire officials, and toll authorities, began to walk, climb, and crawl on, around, and under many of the Nation's bridges and tunnels. The following year, DHS independently sponsored several assessment studies and security retrofit projects on major bridges and tunnels.

The field actions provided valuable feedback—an early focus on details—for the R&D effort. The detailed assessment and analysis of the vulnerabilities outlined earlier through the needs assessment and later by the engineering assessment teams began to quantify effects.

Strategic Focus Areas for Security Research



Source: FHWA.

Thus began the fine-tuning of retrofit measures and an inventory of potential restrictions on proposed countermeasures. The original focus was on vehicle-borne charges, but the engineering assessment teams found alternative attack methods to be feasible, so where possible the researchers factored those into the development of countermeasures.

The field investigations helped identify long-term issues and focus implementation. Other issues considered by the researchers included size and weight limitations on existing structures, especially older ones; material and geometric restrictions; practical restrictions imposed by construction, maintenance, and inspection; and the need to coordinate retrofit designs and hardware with those from other retrofits.

Surveillance Research

State DOTs and other infrastructure owners needed tools to help them assess vulnerability and preparedness. In terms of surveillance systems, new technologies flooded the market after September 11, but the States lacked guidance for choosing among them. DOTs also needed better information on costs, effectiveness, design, and applicability of state-of-the-art technologies for protecting structures. One of the first research studies FHWA undertook was a study to synthesize the latest surveillance technologies and security practices, and develop a protocol to assist infrastructure owners in their decisionmaking processes.

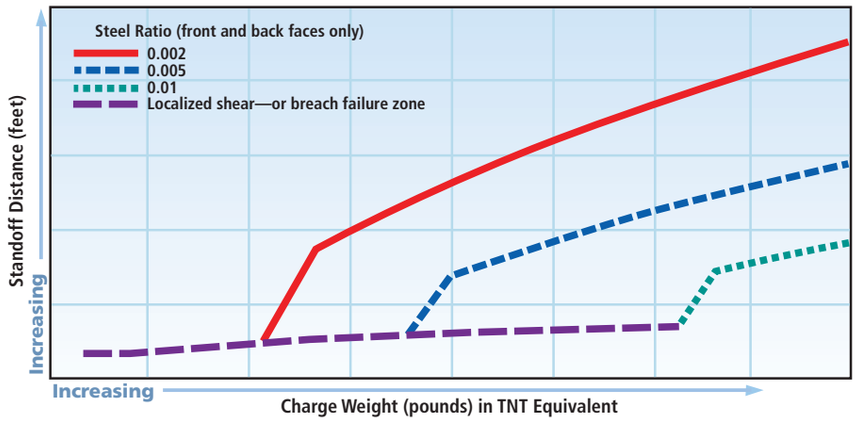
With support from the California, Kentucky, Missouri, New Hampshire, New Jersey, New Mexico, Ohio, and Texas DOTs, FHWA led this Transportation Pooled Fund effort focusing on the state of current and future surveillance and monitoring technologies available both within the United States and abroad. Researchers surveyed bridge and tunnel owners about their existing surveillance and security capabilities, including their experiences with these technologies. The research also included site visits to examine existing systems. The study produced a report, *Bridge and Tunnel Security and Surveillance Technologies,* and a database of available security and surveillance systems. Currently, the report is available by contacting FHWA, and the long-term plan is to make it available through the National Technical Information Service.

Mitigation Research

Although surveillance and security systems such as cameras and sensors, when skillfully used, can detect and deter terrorist activities, is it practical to monitor every truck and van that crosses every bridge and through every tunnel in the country every day? A decade after September 11, is the American public willing to pay for this level of security? This approach might well be appropriate for certain structures but not likely for all.

The next steps, therefore, included concentrating on developing design aids and retrofit measures to

Minimum Standoff Distances For Reinforced Concrete Piers



This graph plots the relationship between the charge weight and the distance from the explosion on a reinforced concrete pier column with different steel reinforcement ratios. For a given standoff distance, walls with higher steel ratios require larger charge sizes to produce the same effect. *Source: USACE for FHWA.*

enable the structures to handle the extreme event loads. Because vehicle bombs are the terrorist weapon of choice worldwide and are a significant concern for highway bridges, FHWA research focused first on mitigating these blast loadings.

To this end, FHWA initiated a study to develop simple design aids, such as standardized blast response curves for bridges. The blast response, or range-to-effect, curves indicate the required threat standoff, the distance from the bomb to a critical bridge component, to prevent maximum allowable level of damage for the explosive charge size. These curves are intended to provide reasonable and conservative estimates of safe standoff distances for vehicle bombs ranging in size. They are, however, based on generic cases requiring many simplifications and assumptions. Because of their limitations, these curves are intended for use not in final design, but as a screening tool to identify those designs that are clearly safe or those that require more detailed analyses.

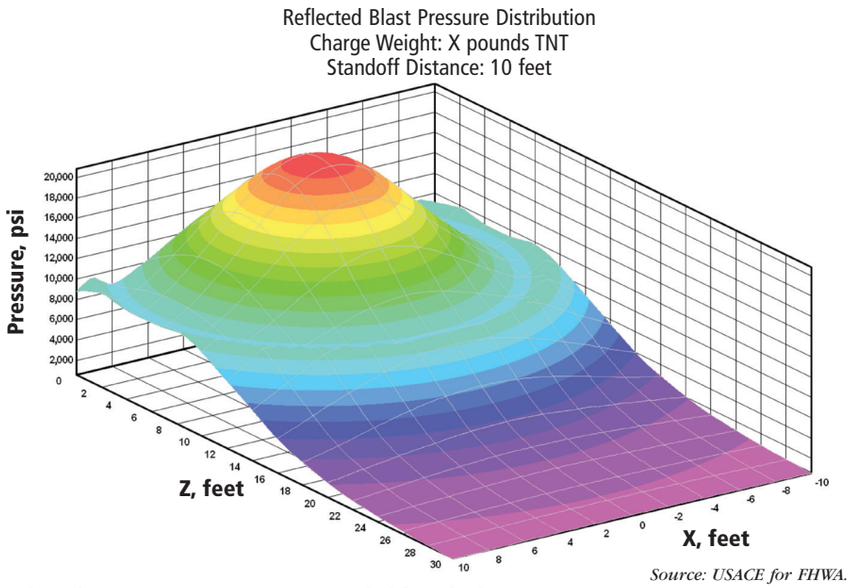
The study has produced three reports that are under review by FHWA: *Vulnerability of Precast Pretensioned Concrete Bridge Girders Exposed to Vehicle-Borne Improvised Explosive Devices*, *Vulnerability of Steel Bridges Exposed to Vehicle Borne Improvised Explosive Devices*, and *Vulnerability Curves for Reinforced Concrete Bridge Piers Exposed to Vehicle-Borne Improvised Explosive Devices*. However, due to the sensitive nature of the subject matter, distribution of the final reports will be limited to those with a need to know.

Another study, titled "Blast Specific Loading Program," adapted an existing USACE computer program to assess the effects of blast loadings on bridges. Conventional Weapons Effects (ConWep) is a software program widely used within the military engineering community to predict the effects of blast loadings from conventional weapons, including terrorist-type vehicular bombs, on buildings. The final product, the Bridge Explosive Loading (BEL) Code, uses the blast algorithms from ConWep (a low-resolution program) as well as algorithms from another USACE program, BlastX, which offers medium resolution. The new BEL Code considers three types of loadings—on decks, on vertical surfaces adjacent to decks, and on columns—and produces pressure distribution curves that designers can use to analyze different load cases.

Ongoing R&D: Steel Bridges

An ongoing transportation pooled fund study initiated in 2004, "Validation of Numerical Modeling and Analysis of Steel Bridge Towers Subjected to Blast Loadings (TPF 5-110)," has successfully provided a much better understanding of blast phenomenology associated with large explosive devices (such as truck bombs) detonated close to or almost in contact with bridges and other structures and has developed mitigation measures. Supporters of the study include FHWA; DHS; the State DOTs in California,

Pressure Distribution Derived from BEL Code



Source: USACE for FHWA.

Using the BEL computer program, bridge designers can create pressure distribution curves like this one to model the effects of a blast on a bridge.

New York, Texas, Washington, and Wisconsin; the Golden Gate Bridge, Highway, and Transportation District; and the Bay Area Toll Authority.

These tests have been the first to be conducted on bridge towers. Researchers performed a series of four progressive tests to study increasingly complex phenomenon. The first series consisted of simple structural configurations, such as flat steel sections to represent the facing of a tower. Through these tests, researchers were able to determine the effect of various charge sizes and standoff distances on these critical bridge components. The next series included more detailed cellular sections. As in the previous series, researchers conducted tests to determine the range of performance behaviors for various charge sizes and range effects. This series also tested retrofit details.

The third series of tests returned to simple configurations similar to those used in the first series and tested different types of energy-absorbing devices, such as fiber reinforced concrete panels and steel plates, to see if they would shield the structure from damage, thereby preventing collapse. The energy-absorbing devices would be sacrificial. The last series tested a more complex, closer representation of an actual cellular steel bridge tower. Researchers also tested retrofits as part of this series and performed "blind" computations using advanced computer analysis to validate the analytical models and predict performance before the actual physical testing. This research and the series of tests represent the beginning of efforts to develop countermeasures to protect these types of bridge members against blast loadings. Reports on each of the test series and an executive summary are under review by FHWA and study participants. The resulting reports will be available for controlled distribution.

New Research

FHWA and DHS now are supporting research by USACE in a followup study to further develop strategies to strengthen steel bridges. The new study adds development of countermeasures to protect several other components identified as critical in the risk analysis. The goal is to study both material combinations and retrofit designs beyond those considered in earlier research. In addition, the researchers will look at design issues including size and weight limitations on existing structures as well as practical restrictions imposed by construction and maintenance.

As in the previous research, steel bridge members will remain the primary focus. In addition to studying specimens constructed with modern steel and bolted connections, the followup research will examine specimens cut from steel members salvaged from recently demolished bridges. The purpose is to extend the range of the earlier project's results to early 20th century steels and to component and connection details characteristic of those bridges. The new study also will quantify the likely effect of wear and corrosion on blast resistance.

Remaining Gaps and Needs

The FHWA publication *Multiyear Plan for Bridge and Tunnel Security Research, Development, and Deployment* identified the steps needed for securing the Nation's infrastructure. The aforementioned projects represent just the beginning. With the support of DHS and USACE, FHWA and other partners in the pooled fund program will continue to advance the state of the practice and help enable State DOTs and other bridge and tunnel owners to identify the most effective ways to enhance the security of their infrastructure.

The security environment is unpredictable, and threats likely will continue to evolve over the coming years. Given the vast bridge population in this country, even narrowing down the number of structures to a smaller subset to receive increased security measures remains a formidable challenge with many variables. Developing solutions will require modeling and simulations, analyses, and experimental testing, all of which will take significant time and resources.

The following questions are among those that researchers will need to address in future studies. Will a given blast-load retrofit change the behavior of the structure? Can the structure support any extra weight, especially in the

Continued on page 27

Partnering with the U.S. Army Corps of Engineers

Why is the U.S. Army Corps of Engineers (USACE) a partner in efforts to address a civilian transportation problem? In a word: experience. The military has long concerned itself with bridge security issues, such as how to attack enemy structures most effectively and how to make U.S. structures more resilient to enemy attack. The Engineer Research and Development Center (ERDC), the research arm of USACE, has led research in this area for many years. Now it is applying this knowledge base to an emerging civilian problem.

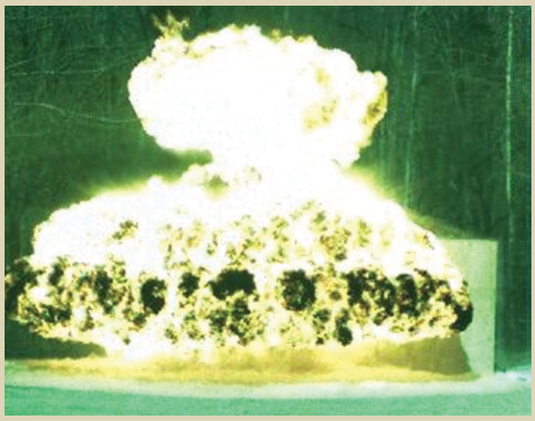
Adapting to a civilian-specific problem posed a number of challenges. For one, military weapons, such as air-to-surface munitions and other elaborate specialty munitions, are quite different from those likely to be used by terrorists. Thus, the knowledge base required significant calibration to the more conventional problem of improvised terrorist devices. In addition, much of the existing knowledge base focused on buildings rather than bridges, which present a different set of problems from the standpoint of mitigation. With buildings, there is always the option to enforce at least some degree of standoff to keep the threat away from the structure—without a doubt the best possible mitigation. Unfortunately, bridge and tunnel owners do not have this choice, as enforcement of any reasonable standoff essentially would require closure of the transportation asset. Thus, owners must instead secure and harden critical bridges and tunnels.

The bridge security knowledge base has grown significantly as a result of this unique partnership, proving beneficial for both agencies. The FHWA-USACE partnership serves to show how, in designing against an aggressive and adaptive threat, separate entities can come together for a common good to produce stronger results.

James C. Ray, P.E.
Senior Researcher
U.S. Army Corps of Engineers' Engineer Research and Development Center

Steel Bridge Towers Subjected to Blast Loadings

This figure shows the outcomes of blast tests conducted under the second series of testing under the study "Validation of Numerical Modeling and Analysis of Steel Bridge Towers Subjected to Blast Loadings (TPF 5-110)." The researchers studied the behavior of steel towers under varied load cases, both in unretrofitted (as is) and retrofitted cases. Because the standoff distance and the loading were the same, the researchers could directly compare the unretrofitted and retrofitted specimens for the three cases: elastic (no permanent deformation after the blast), plastic (notable deformation after the blast), and catastrophic (huge deformation, possibly leading to failure of the structure, after the blast). As shown here, as the loading increased, much more damage was induced in the unretrofitted specimens than in the retrofitted specimens. *Source: USACE for FHWA.*



Unretrofitted

Elastic

Plastic

Catastrophic

Increasing Charge Size →

Retrofitted

Elastic

Plastic

Catastrophic

case of older bridges with severe size and weight limitations? Will the retrofit affect the structure's behavior under other loads, such as seismic loads? Will the retrofit affect the performance of mitigation measures installed to address other types of hazards? For example, how would design and installation details for a blast-load retrofit coordinate with those of an existing or planned seismic retrofit? How will the retrofit affect maintenance and serviceability, since coordinating security retrofits and maintenance is important to ensure that access for inspection is not blocked? Still other issues to consider include how to address sites with little to no standoff distance or options for lane closures and how the retrofit might affect traffic safety. Further still, could a blast-load retrofit be built into existing safety barriers? Most of these issues are of a practical nature, common to many types of retrofits. Security retrofits, however, require developing flexibility and a range in countermeasure details.

Developing protective designs for new bridges in a sense is the easier problem. But in the end, transportation owners need to consider all potential targets, old and new, and the impact of their destruction. A terrorist's choice of target may not hinge on whether it is old or new, famous or not, but simply on whether its destruction is achievable.

In summary, FHWA has identified the following areas for future research regarding bridge and tunnel security:

1. Analysis and modeling to determine predicted effects and to assess and screen countermeasures
2. Substructure and foundation testing for shield retrofits and modified substructure details
3. Steel superstructure testing for retrofits and access controls
4. Concrete superstructure testing for retrofits and access controls
5. Testing of cables and connection details for new materials in replacement projects
6. Testing of behaviors of new materials and coatings
7. Component designs to prevent progressive collapse and removal or reinforcement of vulnerable points or connection details to provide temporary alternate load paths
8. Technologies for rapid repair and restoration following an event
9. Technologies for rapid and accurate structural assessment following an event

All these studies will require verifying and calibrating analytical predictions of the behavior of structural members and individual components when subjected to attack. Also of interest are the performance of currently used or proposed mitigation measures and the testing of recommended variations. Finally, any new retrofit or member designs will require screening of materials, as well as analysis and testing.

Conclusion

Developing solutions for some of engineering's most challenging problems has taken many years, sometimes decades, so expecting the same for this hazard seems reasonable. Nearly a decade has passed since the September 11 attacks, and researchers have learned much about how to protect the Nation's infrastructure, but much work remains.

When dealing with security issues, implementation is always a challenge. Ever-changing threats and the inherently low probability of an attack at any one location make decisionmaking about mitigation measures difficult. Security mitigation is an easy decision—but not an easy job—when the target and consequences are clear. With changing threats and so many potential targets, however, there are limitations on what can be done in terms of structural retrofits and designing for security. An effective security plan, therefore, may be more layered than transportation owners would care for, one that's designed to detect, delay, and deter attacks and to defend when possible. A plan for organized and rapid response and recovery may be the most appropriate and effective security action for most of the Nation's bridges and tunnels.

As underscored in the *Multiyear Plan for Bridge and Tunnel Security Research, Development, and Deployment*, FHWA will continue to conduct research designed to provide highway structures that are safe and reliable for all service conditions—including natural and manmade "conditions" as well. In the process of rehabilitating existing structures, to the extent possible, steps will be taken to incorporate designs and mitigation measures to secure against all potential hazards. Even after the bridge of the future delivers high performance with low maintenance, eliminating hazards, old and new, will continue to be an agency goal.

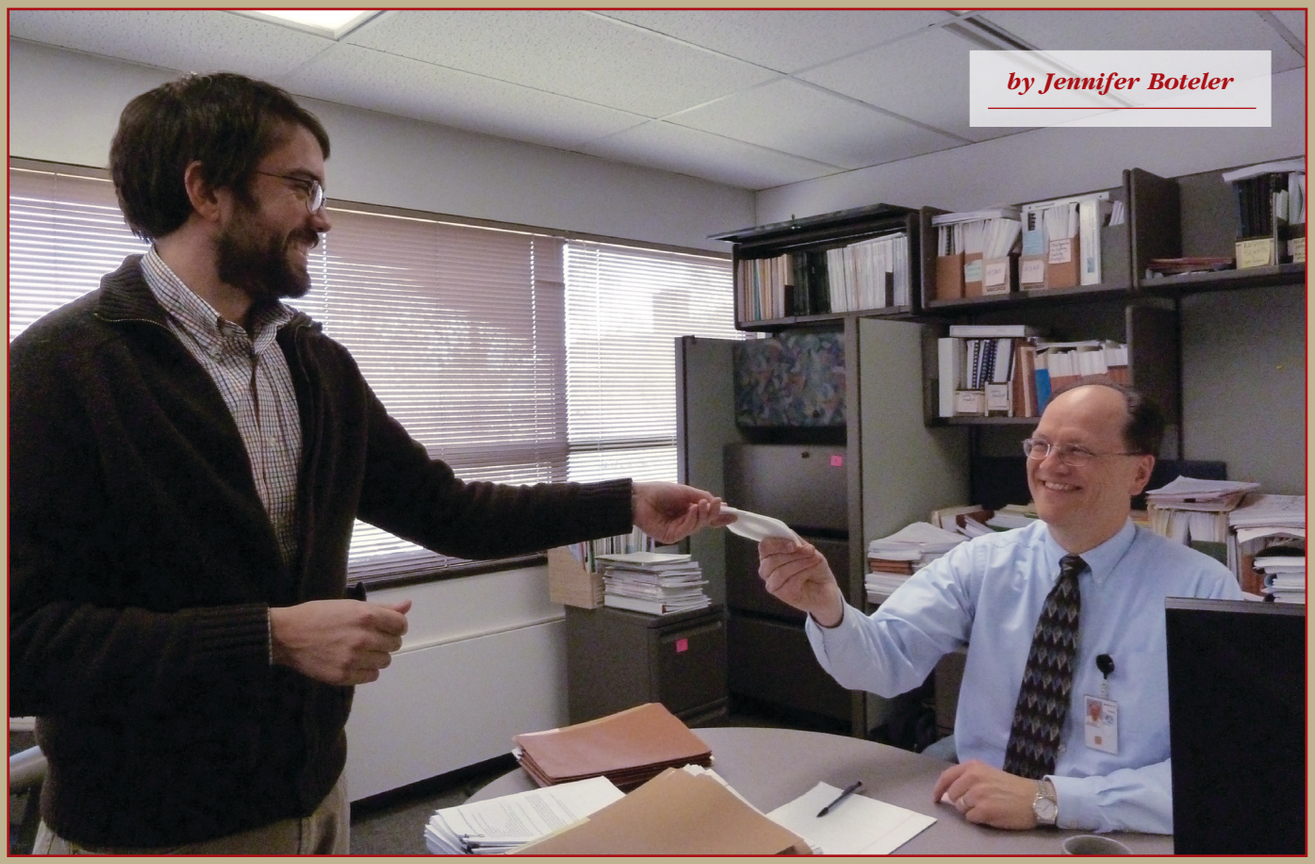
Sheila Rimal Duwadi, P.E., is a team leader in FHWA's Office of Infrastructure R&D at TFHRC. She is responsible for R&D of bridge technologies and methodologies for extreme events and specialty materials. She represents USDOT on the National Science and Technology Council's Subcommittee on Disaster Reduction and recently was appointed a member of the Executive Committee of the Technical Activities Division of the American Society of Civil Engineers' (ASCE) Structural Engineering Institute (SEI). Previously she chaired the SEI Technical Administrative Committee on Bridges and was associate editor for ASCE's *Journal of Bridge Engineering*. Duwadi is a registered professional engineer in Virginia.

Eric Munley, P.E., is a structural engineer in FHWA's Office of Infrastructure R&D at TFHRC. Since 2003, he has been a participant in FHWA's engineering assessment teams to evaluate security issues on field structures, and, more recently, he has been involved in the structures security research program. Previously he directed the research program to develop material, design, and construction specifications and test methods for fiber reinforced polymer composites. From 1997 to 2003, he was chairman of TRB Committee A2C07 (now AFF80) Structural Fiber Reinforced Polymers. Munley received a bachelor of science in civil engineering from the University of Connecticut and a master of engineering from Cornell University. Munley is a licensed professional engineer in Connecticut.

For more information, contact Sheila Duwadi at 202-493-3106 or sheila.duwadi@dot.gov, or Eric Munley at 202-493-3046 or eric.munley@dot.gov.

Masters of Information

In today's ever-expanding universe of knowledge, transportation libraries can help researchers find what they need to make sound decisions.



by Jennifer Boteler

The amount of online information in the world seems to be increasing exponentially. Proof? Just take a look at the Internet. Google recently announced that it has found 1 trillion unique Web pages, but acknowledged that it does not index every page. Further, the company estimates that the number of pages grows by several billion per day.

(Above) John McKenna, former collection management librarian at the FHWA Research Library in McLean, VA, delivers requested data to Dr. Ray Krammes, technical director of the FHWA Office of Safety Research and Development. Such assistance is typical of other Federal, regional, and State transportation libraries.

Beyond the massive volume of indexed pages is an even bigger pool of hidden information stored in databases that remain beyond the reach of standard search engines (the so-called Deep Web). According to a 2006 report, *Exploring the Academic Invisible Web*, 20 billion to 100 billion documents of academic interest reside on the Deep Web. Factor in the proliferation of low-quality information—increasingly abundant thanks to the ease of publishing online—and the challenge of efficient, successful research becomes clearer.

How can researchers navigate so much information, find what they need, and be confident that the information is reliable? For transportation professionals, the issue can take on a level of urgency. Many in the industry make decisions based on the best available science and data, so the safety of the traveling public is at stake. The answer to the question, for laypeople and professionals alike, lies in libraries.

Hear the word "library" and many people think of the public library—shelf after shelf of books, reading rooms, a circulation desk, and patrons coming and going with armloads of books. But transportation agencies have libraries as well, and these are quite different.

Transportation libraries are among what are known as special, or research, libraries. As described in the *Handbook of Information Management*, such a library is staffed by

knowledge (or information) professionals who provide focused information, services, and collections to a specialized clientele. These librarians, therefore, play a critical role in the sponsoring organization's success, helping researchers, administrators, and policymakers accomplish the institution's mission and goals.

Research libraries, which include government, corporate, law, and medical libraries, provide reference and research support. Services include both ready and indepth reference searches. Ready reference involves quick answers to fact-based questions or those that can be answered with a brief piece of information. Indepth reference includes comprehensive literature searches (subject-specific searches for current and historical published research) and research concerning best practices, case studies, legal issues, patents, and other detailed and thorough searches for information.

Transportation libraries at the Federal, State, regional, and local levels play a significant role in providing information that supports transportation policy, regulations, research, operations, and technology transfer. Here's how they do it.

Helpful People

Generally, librarians are trained and skilled in identifying and locating accurate, relevant information. They are adept at helping researchers narrow their queries to the most essential or key documents in a field of study.

"Librarians have the helper gene," Mary Ellen Bates, president and founder of Bates Information Services, told attendees at the Xtreme Reference conference held in October 2010 in Laurel, MD. "Even though librarians have a primary customer base, they generally will help anyone who calls them for assistance, or refer them to someone who can. Whereas some professionals abide by the axiom 'Information is power' and hoard information so they can retain power, librarians willingly and proactively share information."

In public libraries, reference librarians are knowledgeable about the various databases and platforms to find information. They direct patrons to the most relevant resources and may even instruct them how to use the resources.

In research libraries, librarians frequently do background literature reviews for customers. They add value to the search process. Research librarians do not just run searches using keywords provided by customers and then send them raw search results—they synthesize information by evaluating the results, removing irrelevant and out-of-scope citations, and revising searches as needed to find the most relevant material.

At the 2010 Special Libraries Association's (SLA) Transportation Division business meeting, Rita Evans, library director at the Institute of Transportation Studies at the University of California, Berkeley (left), and SLA President-Elect Cindy Romaine swapped stories. *Photo: Karen Perrin, Illinois Department of Transportation.*

"Librarians are masters of information, literally—they have master's degrees in library and information sciences," said Bates. She noted that librarians have varied backgrounds and undergraduate degrees, often related to the specialized information they provide, such as engineering, natural sciences, psychology, or law.

FHWA's Role

At the Federal Highway Administration (FHWA) Research Library, housed at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA, library staffers spend considerable time communicating with highway researchers in order to understand the nature of the specialized information being requested. Library staff search relevant databases and provide citation lists with abstracts. If a researcher then wants the full text, staff will obtain it from the library's own collections or through interlibrary borrowing and document delivery vendors. The types of documents provided include journal articles, conference proceedings, books, dissertations, research reports, technical standards, and unpublished material.

A recent project involving the Human Factors Team in FHWA's Office of Safety Research and Development offers an example of how the agency's Research Library can help. The Human Factors Team conducts research on the role of human factors in highway operations and safety. Each project typically involves a new safety countermeasure or a highway design that the team has never researched before. The team first conducts a thorough literature review so it can focus the research effort and not duplicate previous investigations.

In 2008, staff at the FHWA Research Library helped the Human

Why Search Engines Aren't Always Enough

Deep Web: Search engines cannot access most pages created dynamically by individual database searches or restricted material.

Searching capability: Search engines lack the kind of precision searching tools that databases offer. Because general search engines do not employ controlled vocabularies or allow subject searching, users may need to use more search terms to get the results they want. They will likely retrieve many pages that have the terms on them but are irrelevant. Furthermore, an inability to limit by date and sort items means that users may have to sift through hundreds of sites to find relevant documents.

Credibility: Most databases provide citations and/or full text for peer-reviewed journals, conference papers, reports, and more. Because search engines retrieve results from the entire surface Web, searches will retrieve personal pages, unpublished documents, and other material posted in an uncontrolled environment and often lacking sufficient documentation.

Deena Adelman, FHWA Research Library

Deena Adelman (left), reference and interlibrary loan librarian at the FHWA Research Library, delivers material to Oscar Suaznabar, hydraulics research assistant at the J. Sterling Jones Hydraulics Research Laboratory.

Factors Team conduct a literature review on the possible effects of commercial electronic variable message signs used for outdoor advertising on driver safety. The purpose of the review was to gather information on the latest research methods and techniques involving this technology since the last FHWA report on the topic was published in 2001. Library staff performed multiple literature searches in library subscription (proprietary) and Internet databases covering the legal, commercial, environmental, engineering, and psychological aspects of using these signs.

Over time, the Research Library continued supporting the project as the Human Factors Team examined different aspects of the issue. Additional literature searches covered messaging in the right-of-way; drivers, signs, and clutter density; eye movements, glances, and fixations while driving; and illumination and luminance standards for billboards.

"The librarians carefully listened to the researchers to understand what was needed and then provided useful tips on how to proceed," says Vaughan W. Inman, a contractor with Science Applications International Corporation (SAIC), who works with the Human Factors Team. "They suggested keywords we had not considered, which resulted in critical finds."

According to Inman, the librarians delivered copies of rare documents in 1 to 2 days, provided access to electronic copies through library subscriptions to various full-text databases that the project otherwise could not afford to access, and found and delivered copies of unpublished documents the research team was unlikely to have found on its own. Turning up elusive documents sometimes required contacting authors directly to obtain courtesy copies of articles or prepress drafts.

"The Human Factors Team has benefited in many ways from having an onsite library with professional librarians," Inman says. "The most impressive thing I can recall was when I went to library staff with a reference to a study done in the 1950s by a contractor. The study was not published. It had been delivered to a county supervisors meeting in California." Yet Research Library staff members were able to obtain the report—along with an unpublished critique of it by an FHWA employee.

In addition, librarians can help researchers save time and money by reducing person-hours spent searching on their own. "We might have been able to do some of this work ourselves, but not as quickly, and not without busting our budgets," he says. "Before we had access to library resources and services, we'd sometimes expend additional labor paying someone to do the search at another facility."

Growth in Publishing

Contrary to appearances, not *everything* is available electronically on the Internet. Even with the explosion of information coming online, print materials are still in demand. According to Bowker®, a provider of bibliographic information, U.S. title output in 2009 was virtually unchanged from years past—288,355 new titles and editions. However, extraordinary growth occurred in the number of "nontraditional" (largely print-on-demand) books. Bowker estimates that 764,448 nontraditional titles were produced in 2009, a 181 percent increase over 2008.

The National Technical Information Service, the largest central

Members of the TRB Library and Information Science for Transportation Committee are shown here listening to a question from an audience member at the 2011 TRB annual meeting. (Left to right: Sandy Brady, librarian, Louisiana Transportation Research Center; John Cherney, head librarian, Wisconsin Department of Transportation; and Birgitta Sandstedt, director of the Library and Information Centre at VTI, the Swedish National Road and Transport Research Institute.)

Stacks of hardbound reference materials remain a staple among the resources available through NTL.

resource for government-funded scientific, technical, engineering, and business-related information, added approximately 30,000 new titles to its collection during 2010. Nearly 70 percent of those, or approximately 21,000, are recently published technical reports on U.S. Government-sponsored research.

Academic publishing too continues to see steady growth, including the publishing of research findings and conclusions in scholarly journals. According to *The STM Report: An Overview of Scientific and Scholarly Journals Publishing*, "There were about 25,400 active scholarly peer-reviewed journals in early 2009, collectively publishing about 1.5 million articles a year….The number of articles published each year and the number of journals have both grown steadily for over two centuries, by about 3 percent and 3.5 percent per year respectively."

Libraries Create Finding Tools

Most people are aware of the traditional role of libraries in cataloging hardcopy materials and providing online catalogs where users can search for publications by title, author, subject, or keyword. This role has expanded to data and digital materials. And not only do libraries use databases and "finding tools," they also create them.

For instance, the "Transportation Libraries Catalog" (TLCat) is a shared resource of transportation-related books and other publications held in government, university, and transportation libraries across the United States. TLCat is a subgroup of OCLC,® a nonprofit computer service and research organization whose systems help libraries locate, acquire, catalog, and lend library materials. The National Transportation Library (NTL), an enterprise of the U.S. Department of Transportation's (USDOT) Research and Innovative Technology Administration (RITA), created the TLCat in collaboration with leading transportation libraries from State DOTs, academia, and professional organizations. TLCat was made available to the public through the NTL Web site at http://ntl.bts.gov.

To ensure that published transportation research is preserved and accessible, NTL collects, catalogs, and maintains digital copies of technical, research, and policy documents related to all modes of transportation in an online digital repository. NTL also can digitize documents if they were not "born" or submitted in digital format. A variety of organizations provide the materials, including academic institutions, government agencies, and private publishers. Materials of high value to transportation decisionmakers receive the greatest consideration for acceptance. Public access to the repository, which currently contains more than 40,000 full-text documents, is available through the NTL Integrated Search (http://ntlsearch.bts.gov).

Because the terminology used to describe concepts can differ by discipline, geography, and other factors, some organizations have created thesauri of controlled, or standard, terms for their fields of study. For instance, the Transportation Research Thesaurus (TRT), which is owned by the Transportation Research Board (TRB) and maintained by NTL, is a controlled vocabulary of transportation-related terms. Catalogers and indexers use the thesaurus to assign descriptors and subject terms to publications, making it easier for researchers to know which terms to use when searching by subject or keyword. When redesigning its Web site, FHWA recently applied the thesaurus terms to online research and technical publications.

A thesaurus also enables researchers to retrieve records using synonyms or narrower terms. For example, if a researcher conducts a keyword search for "pavement markings" in the NTL Integrated Search, querying the NTL digital repository database, the search retrieves more than 400 records. To narrow the search and to retrieve records where the subject of the publication pertains to "pavement markings," a researcher could search the TRT for "pavement markings" and would discover that the uniform indexing term for pavement markings is "road markings." Rerunning the search in the NTL digital repository database using "road markings" in the TRT Terms dropdown menu, approximately 40 hits are returned. If the thesaurus did not exist and the researcher searched for "pavement markings," he or she would have hundreds of records to review, many of which would be irrelevant because

Examples of Actual Reference Questions

Below are sample ready reference queries from around the country demonstrating the wide variety of information sought from transportation libraries.

- When will the next *Manual on Uniform Traffic Control Devices* be released?
- Where can I find a logo for the now-defunct Interstate Commerce Commission?
- How many motorcycles are registered in each State?
- What is the increase in the number of lane miles in the United States from 1980 to 2003?
- I am looking for a publication by John Viner on roadside safety hardware.
- What is the AASHTO [American Association of State Highway and Transportation Officials] equivalent of ASTM A944?
- Where can I find AASHTO specifications on bridge coatings/paints?
- How many steel bridges are there in the United States?
- I am looking for a 2008 study stating Indiana had more billboards than permitted.
- Where can I find the conditions of highways by State?
- I am looking for testing requirements for signpost attachments.
- How can I determine which highways are subject to the Federal Highway Beautification Act?
- Can American Recovery and Reinvestment Act funds be used for safety projects on local roads and rural minor collectors?
- Can States charge tolls on interstate highways?
- What is the average commute distance?
- How do I apply for a job with the Federal Highway Administration?
- Where can I find crash-test videos of cars striking highway barriers?
- Are there regulations for the blue and white "H" hospital signs on roads?
- Can you provide me with revenues by source for the Highway Trust Fund for 2007?
- How many car crashes are caused by ice and snow on the roads?
- Can you help me find a map of the United States that shows toll roads?
- Can you help me find supporting documentation for an administrative law judge decision?
- Can you help me find a 1985 FHWA memorandum on design criteria for Federal-aid projects?
- What are pavement marking requirements for "keep clear" or "do not block" areas?

pavement markings were mentioned in the abstract but were not the primary subject of the report.

Librarians Network

The old adage about strength in numbers is especially apropos for librarians: If one cannot find the information a researcher is looking for, he or she can consult colleagues who very likely will be able to find it.

"Librarians were the original collaborators, and transportation librarians capitalize on our ability to network with colleagues around the country and the world in order to provide the best possible service to our customers," says Minnesota Department of Transportation (Mn/DOT) Library Director Sheila Hatchell. "It is not unusual for us to get a request for information 'needed yesterday.' If we do not have it in our immediate collection or online subscriptions, we can send a request either to a targeted library or via our transportation librarians' discussion list. If one of our partners has the needed resource, they fill the request, usually immediately."

After the August 2007 collapse of the I-35W Bridge in Minneapolis, MN, transportation libraries across the country supported each other in filling requests they were receiving from customers for information on bridge inspections, safety, standards, plans, and more. The Mn/DOT Library provided enlarged copies of the original bridge construction plans to the FHWA Research Library in response to requests from FHWA researchers investigating the collapse.

The FHWA library, in turn, shared bridge construction manuals and transportation definitions pertaining to inspections to fulfill requests made by congressional staffers.

The Transportation Equity Act for the 21st Century, enacted in 1998, and subsequent legislation direct NTL to lead networking efforts and improve information sharing in the transportation community by coordinating with public and private transportation libraries and information providers. Today, NTL provides leadership and coordination in developing regional transportation knowledge networks, which comprise the National Transportation Knowledge Network (NTKN).

"The NTKN is a disseminated network of transportation organizations collaborating to improve information access, exchange, use, and preservation for their employees, partners, and stakeholders and the broader transportation community," says Leni Oman, director of the Washington State Department of Transportation's (WSDOT) Office of Research and Library Services. "Employees spend up to 35 percent of their time looking for information. The NTKN will help us improve productivity through strategic information management."

So far, three regional TKNs have been established—the Eastern Transportation Knowledge Network, Midwest Transportation Knowledge Network, and Western Transportation Knowledge Network. Each has its own requirements for membership, but generally the networks are open to any organization that has a collection of transportation information, such as engineering records, maps, planning documents, environmental impact statements,

Attendees of the 2008 annual meeting of the Library Connectivity Pooled Fund Study listen to a presentation on advances in networking among transportation libraries. *Photo: Nick Champion, Louisiana Transportation Research Center.*

Kendra K. Levine, of the Institute of Transportation Studies Library at the University of California, Berkeley, speaks at the second annual NTKN meeting. *Photo: Jerry Baldwin, Midwest Transportation Knowledge Network.*

data files, and technical reports. Member organizations are staffed by trained personnel, such as librarians, records managers, planners, and data providers. Current membership reflects a broad range of information providers: Federal, State, and local governments; universities; trade associations; and corporations.

In addition to participation in the networks, members are engaged in grassroots efforts to centralize and digitize information to ensure broad distribution. For example, the Eastern Transportation Knowledge Network has undertaken the Electronic Digital Collaboratory project to make more transportation content available online through TRB's Transportation Research Information Services (TRIS) database and the NTL digital repository. The network is targeting high-use, high-request, and high-value documents in the public domain—items that researchers ask for frequently, but few people seem able to find. Rather than housing such documents in individual libraries, digitizing them makes them accessible to potential users across the country through their desktop or laptop computers. The project already has contributed to the digital repository about 150 documents that otherwise would not have been available online.

States on the Go

States also are developing modern transportation libraries. For instance, the Iowa Department of Transportation Library, housed at the Institute for Transportation at Iowa State University, created the "Historic Archives Digital Collections," freely accessible to anyone online. The trove collects, preserves, protects, and makes available photographs, maps, artifacts, and films related to transportation in Iowa.

"History plays a defining role in the ever-evolving formation of public transportation policy," says Hank Zaletel, a librarian with the Iowa Department of Transportation Library. "The past is used at all levels of planning to understand the present because it provides a point of reference when assessing choices and justifying decisions."

In Minnesota, Mn/DOT conducted focus groups with its employees and then incorporated new technologies into the redesign of its library space. The additions include Wi-Fi; social networking tools such as Facebook, LinkedIn, Twitter, YouTube, and WordPress; and e-book readers, which can be checked out and used by employees to read electronic books from the library collection.

"Finding State transportation data is difficult," says A.J. Million, of the Missouri Department of Transportation (MoDOT) Library, which is a joint effort of MoDOT and the Missouri State Library. "The Federal Government provides national figures, but regional data often fall through the cracks. States have different priorities, and their separate methodologies and reporting systems lead to inconsistency."

To help fill the need for State-level data, the MoDOT Library, in consultation with the Midwest Transportation Knowledge Network, created "State Stats," available at http://members.mtkn.org/measures. The site uses an open source content management system for data mining to provide centralized access to statistical publications produced by State transportation departments.

Looking Ahead

Additional resources are on the horizon. For instance, RITA's Office of Research, Development & Technology and the NTL are building a Knowledge Management System, which is a Web-searchable database of USDOT's research, development, and technology projects. The system's first phase contains information on USDOT-funded research projects from 2009 through present. This version provides USDOT staff and external stakeholders with an opportunity to test the system and provide feedback on its content and functionality.

Also, a collaborative effort recently was undertaken to combine the records of the International Transport Research Documentation (ITRD) database of the Joint Transport Research Centre of the Organisation for Economic Co-operation and Development (OECD) and the International Transport Forum with the records from TRB's TRIS database to create a newly integrated database for the global transportation research community.

The integrated product, dubbed TRID—the TRIS and ITRD database—is be the world's largest database covering current projects and published transportation research. TRID is a multilingual database, and, when launched at TRB's annual meeting in 2011, offered more than 900,000 records covering all modes and disciplines of transportation. TRID is available to the public for free through TRB's Web site at trid.trb.org. (For more information, see "Database Brings Together Extensive Transportation Records" in Along the Road on page 36 in this issue of PUBLIC ROADS.)

Not long ago, FHWA Research Library staff answered a request for an out-of-print 1996 manual by sending a link to the full text online (contained in the Deep Web) and explaining how to check out the library's hardcopy. The researcher's emailed response points to the important role transportation libraries across the country play—and will continue to play as the universe of information becomes more crowded: "Thanks! I could not find it! I searched Google, our intranet, etc. This is all I need. It pays to ask a librarian!"

Jennifer Boteler is a contractor with MacroSys, LLC, and serves as the supervisory/reference librarian at the FHWA Research Library. Previously, she was a research librarian at WSDOT and the Washington State Library, and a t academic and law libraries. She has a bachelor's degree from West Virginia University and master's degree from North Carolina Central University.

For more information, contact Jennifer Boteler at 202-493-3071 or jennifer.boteler.ctr@dot.gov.

ARE YOU FUTURE READY?

SLA 2011 Conference for Research Librarians

The Special Libraries Association (SLA) is an international organization of information professionals and special librarians in corporations, governments, academic institutions, and the scientific community who use their skills to advance the missions of their organizations.

At the **SLA 2011 Annual Conference & INFO-EXPO**, attendees will have an opportunity to break free from the old ways of thinking and walk away empowered, energized, and ready for what's next!

SLA Transportation Division programming will include the following:

Sunday, June 12
- Government and Transportation Research Information Committee (GTRIC) Roundtable

Monday, June 13
- OMG, The Millennials Are Coming! (cosponsored with the Education Division)
- Success Stories of Solos (cosponsored with Solo Librarians Division)

Wednesday, June 15
- Energy Issues in Libraries: Biofuels and Other Alternative Energies (cosponsored with the Environment and Resource Management Division)

Learn more at www.sla.org/philly2011.

SLA 2011
Annual Conference & INFO-EXPO
12 – 15 June • Philadelphia, Pennsylvania USA

Photo: Bryan Lathrop for Philadelphia Convention & Visitors Bureau/Weaver

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

FHWA Releases Model Language for Climate Change in Transportation Plans

Discussion of climate change is becoming more common in transportation planning documents. Many State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) recognize the role played by transportation policies and investments in contributing to climate change and, conversely, the potential impact of climate change on transportation systems. Currently, there is no Federal regulatory requirement for State DOTs and MPOs to consider climate change in transportation plans. However, some State agencies have created their own models for integrating climate change into their transportation plans.

To provide guidance for agencies, the Federal Highway Administration (FHWA) produced *Climate Change—Model Language in Transportation Plans* (FHWA-HEP-11-002). The document provides an introduction to climate change and answers questions such as "How does transportation contribute to climate change?," "What steps should transportation agencies take to address climate change?," and "What existing policies and programs on climate change are relevant to the transportation plan?" Although some general discussion of climate change is applicable to plans in any State or region, a majority of the language is specific to the particular policy and planning contexts of the various States, MPOs, and municipalities represented in the examples in the document.

For more information, visit www.fhwa.dot.gov/hep/climate/model_language/index.htm.

Technical News

New Tool Determines Pavement's Health

FHWA recently developed an analysis tool that can help determine the condition of a road network in terms of its remaining service life. The Pavement Health Track is designed to determine the health of pavements under various conditions, such as rural or urban environments or climates, and a range of applications, including individual projects, highway networks, and corridors within a State or crossing State lines.

The software requires pavement data inputs from the Highway Performance Monitoring System 2010, or a State can use data from its pavement management system. Included is an option for inputs on material properties, climate, and loading. If these data are unavailable, the program contains a compiled dataset of default inputs pulled from sources such as the FHWA Long-Term Pavement Performance program and National Climatic Data Center.

The tool offers a library of charts, geographic information system maps, and reports that users can customize. Ultimately, these materials can help decisionmakers visualize the analysis results and use the information to determine improvement needs and distribute funds accordingly. FHWA will work with State DOTs to identify opportunities for improving the tool and make periodic updates.

The tool is available on FHWA's Web site at www.fhwa.dot.gov/pavement/healthtrack.

Wireless Multiplex Systems Offer Improved Vehicle Connectivity

A patented technology (U.S. patent No. 7,525,931 B2), wireless multiplex systems, could change how devices in a vehicle work. Currently, drivers and passengers can control the features and functions in vehicles, such as up-down window systems and door lock-unlock mechanisms, because they are interconnected through complex wiring systems housed within vehicle doors. The wireless multiplex system would link such functions wirelessly, eliminating the need for extensive wiring in the body of a vehicle to connect door systems.

The system includes four or five short-range wireless controllers that send and receive signals positioned at locations within the vehicle such as the driver door and liftgate. Devices (such as door lock-unlock) are coupled to and controlled by each of the controllers. The door modules form a virtual network so they can communicate messages to each other for controlling the devices. A wireless node, such as a smartphone, is capable of becoming part of the virtual network to further control at least one of the devices.

The wireless multiplex system has many benefits compared to the traditional wired system. The complex routing of wires through vehicles is labor-intensive and time-consuming. Furthermore, the bundles of wires take up space and add mass to the vehicle. Getting rid of the wires would improve the door assembly process and, by reducing vehicle mass, improve fuel economy. Drivers and passengers would benefit from the enhanced door system reliability, faster service diagnostics, and reduced cost of operating vehicles because of improved fuel economy.

For more information, contact Mohammed Yousuf at 202-493-3199 or mohammed.yousuf@dot.gov.

Public Information and Information Exchange

Virginia Campaign Seeks Employers' Help to End Distracted Driving

In November 2010, the Virginia Department of Transportation (VDOT) joined with the Dulles Corridor Metrorail Project, AAA Mid-Atlantic, and other partners to launch an employer safety pledge as part of its "Orange Cones. No Phones." campaign in Northern Virginia. The goal of the pledge is to have 100 regional employers commit to taking steps to reduce distracted driving.

Tom Saunders, VDOT

Virginia Secretary of Transportation Sean T. Connaughton holds a sign reading "Orange Cones. No Phones." near Tysons Corner, VA.

According to a survey by AAA Mid-Atlantic and the contractor responsible for constructing the Capital Beltway (I–495) high-occupancy toll lanes, more than 50 percent of drivers on the Virginia side of the Capital Beltway use their phones while driving. Fifty-seven percent of these drivers say they do so because they feel the need to give immediate responses to work calls or messages.

Regional businesses and organizations that take the employer safety pledge commit to increase awareness of the dangers of distracted driving in construction work zones. To assist the committed organizations, campaign partners will provide an online toolkit with materials and information (such as safety tips for drivers, copy and banner advertisements for Web sites, and social media resources) specifically designed to reduce distracted driving.

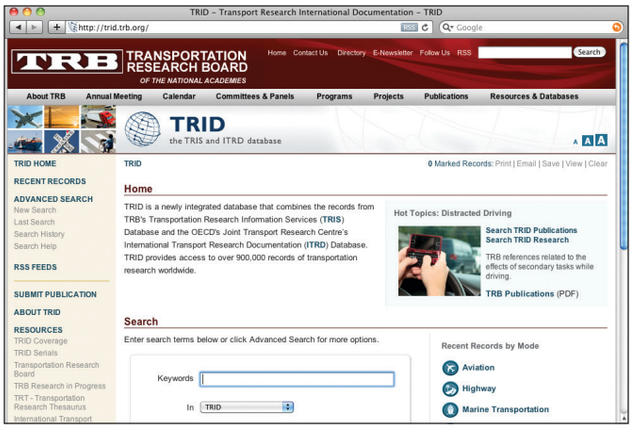
For more information, visit the campaign's Web site at http://orangeconesnophones.com.

VDOT

Database Brings Together Extensive Transportation Records

Recent efforts combined the records of the International Transport Research Documentation (ITRD) database of the Joint Transport Research Centre of the Organisation for Economic Co-operation and Development and the International Transport Forum with the Transportation Research Board's (TRB) Transportation Research Information Services (TRIS) database. The result is the Transport Research International Documentation database, or TRID—the TRIS and ITRD database. Through TRID, users have access to one database that includes transportation research from around the world.

TRID is a free-access, multilingual database with records in English, French, German, and Spanish. The database includes more than 900,000 records of published or ongoing research that are indexed using TRB's Transportation Research Thesaurus or the multilingual ITRD thesaurus.



TRID offers simple and advanced query screens, as well as browsing of recent publications by mode or by "hot topics." The database provides links to the full text of documents, when available, or to direct ordering information. TRID enables users to print, download, email, or share search results, and offers users the ability to subscribe to Really Simple Syndication (RSS) feeds to be notified of the latest publications on a specific topic.

For more information, visit http://trid.trb.org.

TRB

Bridge Replacement Launched At Busy West Coast Port

In November 2010, FHWA Deputy Administrator Greg Nadeau joined representatives from the State of California and the Port of Long Beach to launch the Gerald Desmond Bridge Replacement project, a $950 million undertaking. The 43-year-old bridge is a vital link between the Port of Long Beach and Los Angeles but is no longer reliable enough to fulfill its function effectively because of deterioration.

The Gerald Desmond Bridge, shown here, will be replaced over the next 5 years to better serve the Port of Long Beach, CA.

The Port of Long Beach is the west coast's second busiest port, which requires the Gerald Desmond Bridge to facilitate the movement of more than 10 percent of the Nation's waterborne cargo. The deteriorating condition of the existing bridge requires safety netting beneath the deck to keep debris from falling into the shipping channel. In addition, the current bridge measures only 155 feet (47.2 meters) high, which is too low to allow some cargo ships to pass safely beneath it.

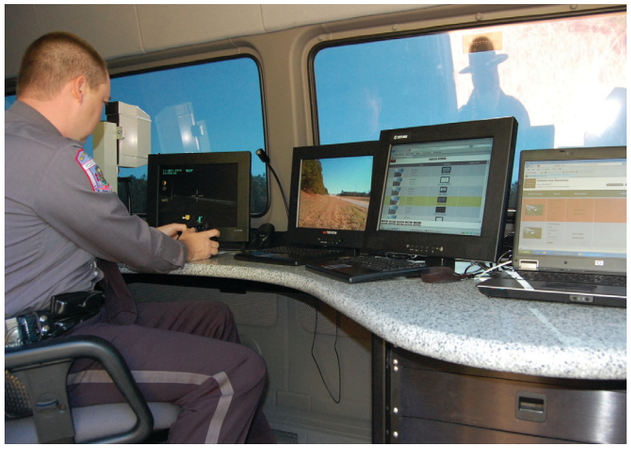
The replacement bridge is a joint project by the California Department of Transportation and the Port of Long Beach. The new bridge will be 50–60 feet (15–18 meters) taller than the current one, making the shipping channel more accessible to cargo vessels and increasing the volume of imports and exports passing through the port.

For more information, visit www.polb.com/about/projects/gdb.asp.

Mississippi Implements "Smart" Roadside Enforcement

The Mississippi Department of Transportation (MDOT) is partnering with the Federal Motor Carrier Safety Administration to address the problem of unregistered, overweight, out-of-service commercial vehicles continuing to operate on Mississippi roads. The increased efforts are made possible by a $3.5 million Commercial Vehicle Information Systems and Networks grant. The goal is to make highways safer by using more efficient ways to inspect trucks.

MDOT is using a variety of enforcement measures to cover the entire State and tie into a central database for sharing information. Measures include the latest "smart" technologies such as roadside mobile applications installed at a fixed weigh station on I–10, virtual weigh stations on secondary roads used to bypass the fixed scales, and a mobile Smart Roadside Inspection System van with infrared capability for use in remote areas or on highways without scales.



Steven Foote

An enforcement officer in Mississippi works at the command station inside the Smart Roadside Inspection System van.

When a truck triggers the process, weigh-in-motion sensors, license plate and USDOT number readers, and overhead and infrared cameras send information and images to databases using wireless connections. By using the information stored in the database, enforcement officers can determine whether the vehicle is allowed to pass or must stop for further inspection and credential verification. This process reduces the number of vehicles stopped randomly for routine inspections, enabling officers to focus on risky carriers while allowing legal carriers to keep moving.

MDOT

Now Available: New Asset Management Guide

A new publication from the American Association of State Highway and Transportation Officials (AASHTO) and based on a National Cooperative Highway Research Program project aims to help transportation agencies address strategic questions they confront in managing the surface transportation system. The *AASHTO Transportation Asset Management Guide—A Focus on Implementation* complements the 2002 AASHTO *Transportation Asset Management Guide* and provides more detailed, hands-on guidance on implementing transportation asset management concepts, principles, performance targets, and strategies. In addition, the publication addresses analysis methods, data collection, and application of information from management systems, including tools to evaluate return on investment. The guide includes examples of strategies for enhancing communication and information-sharing among decisionmakers and elected officials.

This publication supports the goal of asset management, which is to minimize the life-cycle costs for managing and maintaining transportation assets, including roads, bridges, tunnels, rails, and roadside features. An asset management approach can lessen long-term costs and improve the credibility of the decisionmaking process through objectivity and a sound technical basis.

For more information, download a brochure at www.fhwa.dot.gov/asset/hif10023.cfm or visit http://assetmanagement.transportation.org. To purchase the guide, visit https://bookstore.transportation.org.

DVD Shows Importance of Rumble Strips on Reservations

The Roadway Safety Foundation (RSF) recently released an educational DVD titled "Rumble on the Reservation." The 11-minute video, available at no cost, introduces audiences to tribal communities that have seen motor vehicle crashes, injuries, and fatalities fall significantly after incorporating rumble strips into roadway safety projects on tribal lands.

"Rumble on the Reservation" features transportation planners and safety experts from various tribal communities, as well as the Federal Government, explaining the versatility and cost-effectiveness of rumble strips. The video provides real-world examples of locations where rumble strips have been deployed successfully. RSF produced the DVD in conjunction with the Tribal

Road Safety Foundation

This screenshot from the "Rumble on the Reservation" DVD shows Dennis Trusty, director of the Northern Plains Tribal Technical Assistance Program, discussing the lifesaving benefits of edgeline and centerline rumble strips.

Technical Assistance Program at the Michigan Technological University.

According to RSF, one of the reasons tribal communities stand to benefit so greatly from rumble strips is that many tribal lands are served primarily by two-lane rural roads. These roads are particularly prone to high fatality rates and elevated risks of roadway departures. In fact, nearly 60 percent of fatal crashes are roadway departure crashes.

For more information, download an informational brochure at www.roadwaysafety.org/wp-content /uploads/res-brochure.pdf. For a copy of the DVD, contact Cathy Gillen with RSF at 202-857-1203 or cathygillen@roadwaysafety.org.

RSF

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, Paula Magoulas, via email (paula.magoulas@dot.gov), telephone (202–493–3398), or mail (Paula Magoulas, 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 Diane Turchetta

A Home for Transportation and Climate Change Resources

Addressing climate change and reducing greenhouse gas (GHG) emissions are major policy issues worldwide. According to the U.S. Environmental Protection Agency's (EPA) *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008*, the transportation sector is responsible for 32 percent of all carbon dioxide emissions from fossil fuel combustion in the United States. Given this significant contribution to GHG emissions, reducing the transportation sector's fossil fuel use represents an important component of Federal, State, and local efforts to cut emissions.

There is an additional reason for the transportation sector to be concerned about climate change: potential impacts on operations and infrastructure. Increases in temperature, sea level rise, and the intensity and number of storms could have serious impacts on the transportation network. For example, sea level rise could damage infrastructure in low-lying areas and make coastal highways and bridges more vulnerable to storm surges. (For more information, see "Taking Stock: Climate Change and Transportation" in the March/April 2010 issue of PUBLIC ROADS.)

The U.S. Department of Transportation (USDOT) announced the Transportation and Climate Change Clearinghouse Web site at the Transportation Research Board's 88th Annual Meeting in January 2009. The Web site, accessible at http://climate.dot.gov, is a one-stop shop for information, resources, tools, and strategies for addressing climate change in the transportation sector.

"New information sources addressing transportation and climate change are increasingly available," says Linda Lawson, cochair of the USDOT Center for Climate Change and Environmental Forecasting. "However, until we created the clearinghouse, they required extensive searches to locate. Now, all this information is accessible in one place."

Developing the Clearinghouse

USDOT created the clearinghouse under the National Cooperative Highway Research Program with additional funding from the Department's Center for Climate Change and Environmental Forecasting. To develop the site, USDOT enlisted help from representatives from EPA and State departments of transportation (DOTs). Eleven practitioners from State DOTs and metropolitan planning organizations participated in usability tests on a beta version of the site, providing valuable insights on content, functionality, and ease of navigation.

Flush with Content

The clearinghouse facilitates peer-to-peer information sharing and technical capacity building by serving as a virtual portal for information exchange between Federal, State, and local transportation practitioners, researchers, and nongovernment organizations. The content covers all modes of transportation—aviation, bicycles and pedestrians, highways, marine transportation, motor carriers, rail, and transit.

Key subject areas include the following:

- Background information on transportation's role in climate change
- GHG inventories, forecasts, and transportation data
- Methodologies for analyzing GHG emissions from transportation
- Strategies for reducing transportation-related GHGs
- Climate change impacts and adaptation strategies
- Federal, State, and local actions and policies

Many State and local governments are setting reduction goals through legislation, regulation, and other policies. States and regional coalitions are developing climate action plans to identify and evaluate feasible strategies to reduce emissions through a combination of public and private sector policies and programs.

The section on GHG emissions inventories provides an overview of the U.S. inventory, trends in national and State-level emissions, and links to resources related to State and regional inventories. Under GHG reduction strategies, the site highlights fuels and vehicle technologies, transportation planning strategies such as travel demand management programs, and operations strategies such as incident management, traveler information, and freeway management. A resources tab provides links to related hearings, books, conference presentations, and newsletters.

Other Features

The clearinghouse includes an advanced function that enables users to search using multiple keywords, resource type, year, format, and language. The site also features a calendar with relevant conferences and events, a glossary of terms, and links to related organizations' Web sites. Since its launch, the site consistently has seen between 4,000 and 5,000 unique visitors a month.

For information on how to submit materials to the clearinghouse, visit http://climate.dot.gov/documents/submissions.pdf or contact Roger Garren, reference librarian at the National Transportation Library, at roger.garren@dot.gov.

Diane Turchetta is a transportation specialist in the Federal Highway Administration's Office of Planning, Environment, and Realty.

Training Update

NATIONAL HIGHWAY INSTITUTE

by Lilly Pinto

Reducing Crash Frequency and Severity

More than 33,000 traffic fatalities occurred on U.S. roadways nationwide in 2009 according to the National Highway Traffic Safety Administration. The sheer number of fatalities underscores the need for effective tools to help the transportation community predict crash frequency and severity, and then make appropriate decisions about how to improve safety. To fill this need, the American Association of State Highway and Transportation Officials (AASHTO) helped develop the *Highway Safety Manual* (HSM). The HSM is the first nationally recognized resource for quantitative information on predicted crash frequency of elements considered in road planning, design, construction, operation, and maintenance. In short, the manual helps take the guesswork out of safety analysis.

The National Highway Institute (NHI) offers a suite of courses to help transportation professionals at every level and function, from planners and designers to engineers and project managers, use the HSM to improve transportation systems and to help prevent traffic injuries and fatalities. HSM's application also can lead to more effective planning for safety investments.

"The *Highway Safety Manual* introduces an opportunity for safety impacts to be evaluated alongside environmental and operational impacts, which wasn't possible before," says Esther Strawder, safety specialist with the Federal Highway Administration's (FHWA) Office of Safety. "By putting the HSM's safety analysis tools into practice, transportation professionals can have a substantial impact on reducing crashes and saving lives."

Tools, Techniques, and Benefits

Prior to the HSM, safety considerations often carried little weight in the project development process. The HSM aims to provide transportation professionals with current knowledge, techniques, and methodologies to quantify safety impacts and conduct safety analyses in a technically sound and consistent manner.

The HSM is divided into four parts that outline the tools and techniques for quantifying safety impacts within a locality. Part A describes the purpose and scope of the HSM, explaining the relationship of the manual to planning, design, operations, and maintenance activities. Part B includes steps for identification of improvement sites, diagnosis, countermeasure selection, economic appraisal, project prioritization, and effectiveness evaluation. The predictive method for estimating the expected average crash frequency of a network, facility, or individual site is highlighted in Part C. The final component, Part D, includes a catalog of crash modification factors (CMFs), which estimate the change in the expected average crash frequency resulting from modifications to a given site compared to baseline conditions.

Hillary N. Isebrands, FHWA

Training participants in Ames, IA, complete an exercise during a recent session of the course HSM Practitioner's Guide for Two-Lane Rural Highways.

The HSM gives safety engineers the tools to identify locations that are most likely to respond to safety improvements, better evaluate the economic validity of individual projects, and prioritize projects across a system. The HSM also can assist project managers in assessing the safety performance of design alternatives based on their geometric and operational characteristics.

HSM Practitioner's Guide Courses

NHI revised five training courses to specifically highlight the practical application of the HSM.

- HSM Practitioner's Guide for Geometric Design Features (FHWA-NHI-380070)
- HSM Practitioner's Guide for Two-Lane Rural Highways (FHWA-NHI-380070A)
- HSM Practitioner's Guide for Multilane Highways (FHWA-NHI-380070B)
- HSM Practitioner's Guide for Horizontal Curves (FHWA-NHI-380088)
- HSM Practitioner's Guide for Intersections (FHWA-NHI-380105)

The HSM Practitioner's Guide for Intersections course, for example, provides an indepth and comprehensive review of the HSM as it relates to intersections. The course introduces practitioners at the State, county, and local levels to the new techniques and knowledge contained in the manual. During the training, participants complete a series of exercises, such as calculating the number of predicted crashes for a given set of conditions at an intersection based upon the intersection's design and then comparing the predicted crashes to the number of observed crashes.

"This course helps practitioners apply HSM methodology to evaluate intersection operational and safety performance," says Tom Elliott, NHI's training program manager for highway safety. "It also teaches practitioners how to better use scarce resources more efficiently."

For course descriptions, visit NHI's Web site at www.nhi.fhwa.gov.

Lilly Pinto 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.

Harnessing the Value of Ecosystems: The Concept Of Ecosystem Service Markets (Fact Sheet) Publication No. FHWA-HRT-10-075

In January 2010, experts from government agencies, universities, and regulatory and market agencies participated in a workshop to discuss how buying and selling ecosystem services could ultimately lead to a more resilient and sustainable planet. The workshop, Ecosystem Service Markets and Associated Performance Measures, was supported by the FHWA Exploratory Advanced Research (EAR) Program. The fundamental concept of ecosystem service markets (ESM) is that many services an ecosystem provides, such as water quality, flood control, and habitat for endangered species, can be assigned a value and then bought and sold on an open market.

In ESM, the ecosystem services result in a tradable commodity, such as tons of carbon or phosphorus, or a risk management tool, such as insurance against extinction of a species. Some of the workshop participants' long-term vision of ESM is that service providers and buyers can meet in a virtual marketplace that is regulated and approved by agencies with legal authorities under legislation such as the Endangered Species Act and the Clean Water Act.

This fact sheet summarizes the workshop's topics of discussion, including ESM background, benefits, and implementation, and development of a valued ecosystem. The fact sheet also includes information on how advancing ESM could potentially provide the transportation industry with an alternative means of compliance with environmental laws that result in faster permitting, as well as less expensive and better performing mitigation. However, many issues of policy and science must be addressed before such a one-stop shopping market will come to fruition.

Printed copies of the fact sheet are available from the PDC.

Staying in Lane: Intelligent Fusion Of Vehicle Sensor Data (Fact Sheet) Publication No. FHWA-HRT-10-064

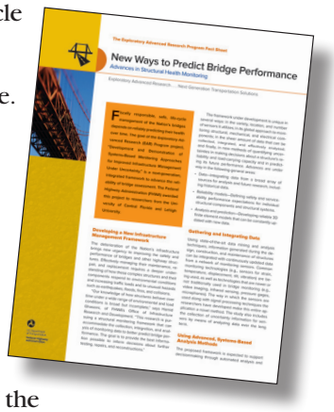
More than 25,000 people die each year in the United States in crashes caused by a vehicle drifting or veering out of its lane. Preventing such crashes through a more accurate and reliable lane-keeping system is the challenge addressed in an EAR project launched in 2008: Intelligent Multi-Sensor Measurements to Enhance Vehicle Navigation and Safety Systems. This fact sheet discusses driver-assisted and automated lane keeping, integration of systems data, the key challenge to combining measurements of lane-keeping systems, and future research efforts.

Recognizing the potential of positioning technologies to prevent thousands of highway deaths, FHWA continues to support efforts to improve their reliability and accuracy. In this project, FHWA is attempting to integrate data from a variety of onboard sensing equipment, such as lane detection cameras, micro-electromechanical systems inertial sensors, high-accuracy nationwide differential global positioning systems, and advanced light detection and ranging systems. Although each of these technologies can contribute data to lane-keeping systems, each also has performance limitations. Project researchers are working to fuse the data from a range of sensors to compensate for those deficiencies. The key challenge is that researchers must correct each sensor's specific, individual error source before they can combine the different but complementary measurements.

Following a successful demonstration of enhanced lane-positioning capability, the project will produce a test methodology for industry use. FHWA's goal is to refine and optimize the data integration algorithms for various driving conditions.

Printed copies of the fact sheet are available from the PDC.

New Ways to Predict Bridge Performance: Advances In Structural Health Monitoring (Fact Sheet) Publication No. FHWA-HRT-10-062



Fiscally responsible, safe, life-cycle management of the Nation's bridges depends on reliably predicting their health over time. The goal of the EAR project Development and Demonstration of Systems-Based Monitoring Approaches for Improved Infrastructure Management Under Uncertainty is to create a new framework for infrastructure management and advance the reliability of bridge assessment. This fact sheet discusses development of the new framework, data gathering and integration, use of advanced systems-based analysis methods, and future efforts regarding predicting bridge health.

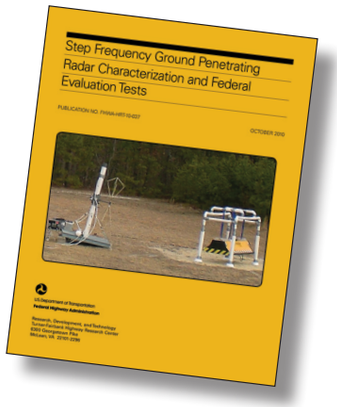
Effectively managing bridge maintenance, repair, and replacement requires a deeper understanding of how bridges and their components respond to environmental conditions and increased traffic loads. Researchers are using state-of-the-art data mining and analysis techniques to integrate information generated during the design, construction, and maintenance of structures with continuously updated data from a network of monitoring sensors. To monitor bridge components, researchers are using sensor technologies for measuring strain, temperature, displacement, tilt, and vibration, and technologies not traditionally used in bridge monitoring such as video imaging, infrared sensing, pressure gauges, and microphones.

This research could lead to significant cost efficiencies in managing transportation structures, while also reducing the cost of information processing and analysis through automated data collection and evaluation processes. Perhaps most important, FHWA expects the structural health monitoring framework to accelerate advances in performance-based assessments of the condition of transportation infrastructure.

The fact sheet is available at www.fhwa.dot.gov/advancedresearch/pubs/10062/index.cfm. Printed copies are available from the PDC.

Step Frequency Ground Penetrating Radar Characterization and Federal Evaluation Tests Publication No. FHWA-HRT-10-037

Step frequency ground penetrating radar (SF GPR) technology offers unprecedented subsurface three-dimensional imaging capabilities. Through previous evaluations and reports, FHWA has determined that SF GPR can be applied to evaluate subsurface infrastructure problems. However, due to SF GPR operating principles, system electromagnetic emissions testing is required to ensure the device will not interfere with other systems that use the electromagnetic spectrum (such as the Federal Aviation Administration's radar tracking or radio astronomy). This report provides a comprehensive emissions characterization and evaluation of an SF GPR system.



For this report, researchers characterized and evaluated an SF GPR system to determine whether it can be operated safely in a proposed configuration that includes frequency notching to remove emissions in specific frequency bands. This emissions testing was conducted with several notching configurations turned on and then turned off to enable researchers to evaluate both scenarios.

Results from initial emissions testing showed that the SF GPR met the National Telecommunications and Information Administration (NTIA) criteria for most frequencies, but some emissions frequencies still exceeded NTIA criteria. The researchers made some system adjustments and conducted followup emissions testing using a final system configuration that meets NTIA criteria for intentional emissions. This report describes the testing in detail, along with a proposed coordination procedure between NTIA and system users to ensure appropriate operation.

The report is available at www.fhwa.dot.gov/publications/research/operations/10037/index.cfm. Printed copies are available from the PDC.

Evaluation of Shared Lane Markings (TechBrief) Publication No. FHWA-HRT-10-044

Shared lane markings (also called sharrows) help convey to motorists and bicyclists that they must share the road. The markings create improved conditions by clarifying where bicyclists are expected to ride and by notifying motorists to expect bicyclists on the road. FHWA sponsored a study to evaluate the impact of several uses of shared lane pavement markings. This TechBrief provides a summary of the methodology, site-specific experiments, and findings from the research.

Researchers conducted experiments in Cambridge, MA, Chapel Hill, NC, and Seattle, WA. The experiments specifically dealt with the shared lane marking design—a road marking applied where a complete bike lane cannot be installed. The cities implemented the markings in a variety of situations and collected data on the operating behaviors of bicyclists and drivers in the traffic stream before and after installation.

According to the report, results indicate that the shared lane markings increased operating space for bicyclists. The study also recorded a decrease in the number of bicyclists riding on the sidewalks. More information is available in the corresponding main technical report of the same title (FHWA-HRT-10-041).

The document is available at www.fhwa.dot.gov/publications/research/safety/pedbike/10044/index.cfm. Printed copies are available from the PDC.

Safety Effectiveness of the HAWK Pedestrian Crossing Treatment (TechBrief)
Publication No. FHWA-HRT-10-045

The high intensity activated crosswalk (HAWK) treatment, now called the pedestrian hybrid beacon, where installed at pedestrian crossings, has the potential to achieve a high rate of driver yielding to pedestrians, especially at major arterials with minor street intersections. FHWA recently sponsored a study to evaluate the safety effectiveness of the beacon treatment, and this TechBrief provides a summary of the study's background, methodology, observations, and conclusions.

At a crossing with the pedestrian hybrid beacon treatment, drivers receive multiple cues to emphasize the potential presence of pedestrians. These cues include a unique configuration of the beacon (two red lenses over a single yellow lens), high-visibility crosswalk markings (ladder-style markings as opposed to only two transverse white lines), a stop bar approximately 50 feet (15 meters) from the crosswalk, 8-inch (20-centimeter) solid lane lines between through travel lanes, illuminated "Crosswalk" signs, and school warning signs. When activated, the pedestrian hybrid beacon uses a red indication to inform drivers to stop.

Researchers studied 21 intersections in Tucson, AZ, where the devices were installed and used two reference groups to compare signalized and unsignalized sites. Since the prime objective of a pedestrian hybrid beacon is to provide pedestrians with safe crossing opportunities, researchers collected and compared data on pedestrian crashes. The study reports a statistically significant reduction in pedestrian crashes at sites with the device installed. More information is available in the corresponding main technical report (FHWA-HRT-10-042).

The document is available at www.fhwa.dot.gov /publications/research/safety/10045/index.cfm. Printed copies are available from the PDC.

Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks (TechBrief)
Publication No. FHWA-HRT-10-046

Researchers have examined many methods to increase the likelihood of drivers yielding to pedestrians in multilane crosswalks at uncontrolled sites with relatively high average daily traffic. In this study, FHWA specifically examined the effects of side-mounted, yellow, light-emitting diode (LED) rectangular rapid-flashing beacons (RRFBs) at uncontrolled, marked crosswalks on driver yielding behavior. This TechBrief provides details on the research methodology, study results, and conclusions.

Researchers conducted a series of experiments at 22 sites in Mundelein, IL, St. Petersburg, FL, and Washington, DC, to examine the efficacy of RRFBs for increasing driver yielding behavior. The researchers also compared the RRFB with a traditional overhead yellow flashing beacon and a side-mounted traditional yellow flashing beacon. Additional variations of the treatment included mounting more units on a median or pedestrian refuge island and aiming the RRFB system to maximize brightness at a target site.

The results showed that RRFBs are an effective tool for increasing the number of drivers who yield right-of-way to pedestrians in crosswalks at sites where drivers previously did not regularly yield to pedestrians.

The document is available at www.fhwa.dot.gov /publications/research/safety/pedbike/10046/index.cfm. Printed copies are available from the PDC.

Crosswalk Marking Field Visibility Study (TechBrief)
Publication No. FHWA-HRT-10-067

Crosswalk markings provide guidance for pedestrians crossing roadways by defining and delineating paths on approaches. To help identify the relative visibility and driver behavior effects of varying styles and patterns of crosswalk markings, FHWA studied the relative daytime and nighttime visibility of three crosswalk marking patterns: transverse lines, continental markings, and bar pairs. This TechBrief includes information on the background, study approach, results, and recommendations.

For this study, 78 participants drove an instrumented vehicle through a predetermined route on the Texas A&M University campus in College Station, TX. The route provided an open road environment that included portions in a typical college setting (such as sidewalks, buildings, and a sports arena) and roads through the agricultural area of the campus, which are more rural in feel. Roadway lighting was present at each of the crosswalk locations. Using the special vehicle instrumentation, researchers measured and recorded various driving performance data.

The research found that participants gave the continental markings and bar pairs similar ratings, both in the daytime and at night. However, the transverse marking ratings showed a difference based on the light level. The participants gave transverse markings lower ratings during daylight conditions and gave them slightly better ratings, although still worse than continental or bar pairs markings, during the nighttime.

The document is available at www.fhwa.dot.gov /publications/research/safety/pedbike/10067/index.cfm. Printed copies are available from the PDC.

Corrections: In a photo caption in the article "A Majestic Showcase" in the March/April 2011 issue, Governor Jan Brewer should have been listed as a republican from Arizona. In the article "Sustainable Streets" in the March/April 2011 issue, David Carlson's email address should have been listed as david.carlson @parsons.com. We regret the errors.

Conferences/Special Events Calendar

Date	Conference	Sponsors	Location	Contact
August 1–4, 2011	National LTAP and Tribal Technical Assistance Program Annual Conference	Federal Highway Administration (FHWA) and the National Local Technical Assistance Program (LTAP) Association	Boston, MA	Dan Montagna 413-545-5403 info@baystateroads.org www.boston2011.org
August 13–16, 2011	ITE Annual Meeting and Exhibit	Institute of Transportation Engineers (ITE)	St. Louis, MO	Sallie C. Dollins 202-785-0060, ext. 149 sdollins@ite.org www.ite.org
August 15–18, 2011	34th National Transportation Public Affairs Workshop	American Association of State Highway and Transportation Officials' Subcommittee on Public Affairs and the Iowa Department of Transportation	Des Moines, IA	Tracey Bramble 515-239-1314 tracey.bramble@dot.iowa.gov www.iowadot.gov/ntpaw2011
August 16–18, 2011	3rd Safe Routes to School National Conference	National Center for Safe Routes to School and the Safe Routes to School National Partnership	Minneapolis, MN	Caroline Dickson 919-962-5835 dickson@hsrc.unc.edu www.saferoutesconference.org
August 20–24, 2011	SASHTO 70th Annual Meeting	Southeastern Association of State Highway and Transportation Officials (SASHTO)	Louisville, KY	Cheryl Caldwell 502-564-3730 cheryl.caldwell@ky.gov www.sashto.org/SASHTO2011
August 21–24, 2011	National Scenic Byways Conference	America's Byways Resource Center and FHWA	Minneapolis, MN	Leah Kohlts 218-625-3301 lkohlts@byways.org www.bywaysresourcecenter.org /events/conferences/2011
August 21–25, 2011	International Conference on Ecology & Transportation (ICOET)	Center for Transportation and the Environment, FHWA, and Washington State Department of Transportation	Seattle, WA	James Martin 919-515-8620 jbm@ncsu.edu www.icoet.net/ICOET_2011
September 14–16, 2011	3rd International Conference on Road Safety and Simulation (RSS2011)	Organized by the Center for Road Safety, Purdue University, and Transportation Research Board	Indianapolis, IN	Dr. Andrew Tarko 765-494-5027 rss2011@ecn.purdue.edu https://engineering.purdue.edu /RSS2011
September 18–21, 2011	APWA International Public Works Congress and Exposition	American Public Works Association (APWA)	Denver, CO	Dana Priddy 816-595-5241 dpriddy@apwa.net www.apwa.net/congress

Introducing FDsys

Millions of Federal documents at your fingertips

The Federal Digital System (FDsys) is home to nearly 50 collections of government information, including congressional, presidential, and agency publications, some dating to the early 1900s. Access is free, and searching is easy and precise.

- Search multiple publications from a single search box.
- Construct complex search queries.
- Access authentic, digitally signed PDF documents, which ensure information integrity.
- Access multiple file formats for each search result.
- Access metadata in standard XML formats.
- Browse by collection, congressional committee, or date.

Find what you're looking for at www.fdsys.gov.

FDsys
FEDERAL DIGITAL SYSTEM
AMERICA'S AUTHENTIC GOVERNMENT INFORMATION

GPO U.S. GOVERNMENT PRINTING OFFICE
Keeping America Informed | www.gpo.gov

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-11-004
HRTM-20/5-11(5M200)E