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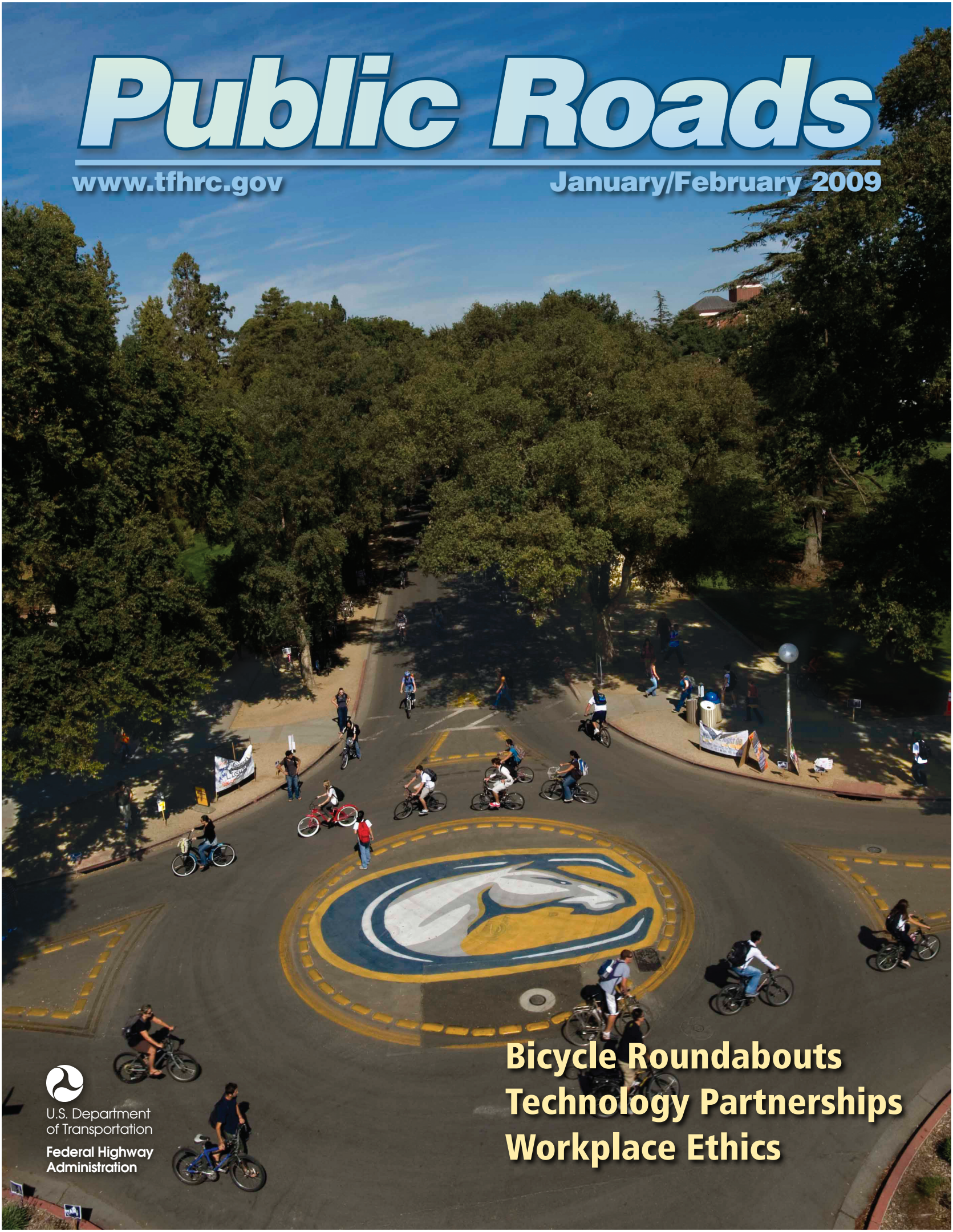

Bicycle Roundabouts
Technology Partnerships
Workplace Ethics

U.S. Department of Transportation

Federal Highway Administration

Public Roads

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

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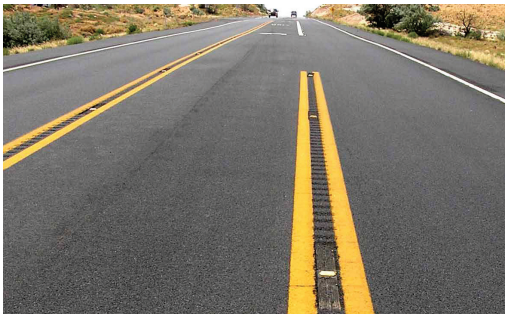
Articles



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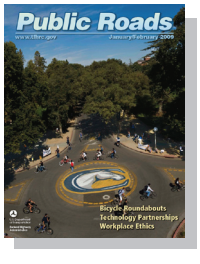

Front cover—Bicyclist- and pedestrian-only roundabouts, such as this one at the University of California, Davis, are increasing in popularity on shared-use paths and on college campuses because they improve safety and traffic flow. Under California law, persons over 18 years old are not required to wear a bicycle helmet; however, doing so demonstrates safe riding practice. See "Bicyclist- and Pedestrian-Only Roundabouts" on page 2 of this issue of PUBLIC ROADS. *Photo: Karin Higgins/UC Davis.*

Back cover—The rising popularity of bicycles, such as these parked near a major lecture hall at the University of California, Davis, has prompted colleges and universities across the country to build roundabouts on campus. UC Davis' extensive bicyclist-pedestrian trail network features more than a dozen roundabouts at key locations throughout campus. Other cities and institutions of higher education are applying the Davis model to their overall transportation plans. *Photo: Karin Higgins/UC Davis.*

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Guest Editorial

Ongoing Testing and Deployment of Safety Measures

The Federal Highway Administration (FHWA), and for that matter the entire highway community, faces immense challenges in reducing the loss of life on U.S. highways. Advances are needed in all four E's of safety: engineering, enforcement, education, and emergency services. On the engineering side, FHWA has researched, marketed, and promoted a number of innovative features and practices. In-service evaluations have proven that many of these measures save lives when used in the proper locations and conditions.

On July 10, 2008, Associate Administrator for Safety Jeffrey A. Lindley issued a memorandum titled "Consideration and Implementation of Proven Safety Countermeasures." The memo and its attachments, which can be found at http://safety.fhwa.dot.gov/policy/memo071008.pdf, encourage development of policies to implement nine proven crash countermeasures and provide guidance on the conditions under which these countermeasures should be considered. The guidance also includes the results of the in-service evaluations, links to reference documents, and the names of FHWA contacts for each countermeasure.

The countermeasures address each of the four safety focus areas: roadway departure, intersections, pedestrians, and speed management. The measures include road safety audits, rumble strips, median barriers (including cable barriers), safety edges, roundabouts, turn lanes, yellow signal change intervals, pedestrian refuge areas, and walkways. Although some of these features have been in use for years, others are just now being deployed on a systemic basis. Each has traveled the path from innovation to proven and accepted technology and practice.

The needs of all road users—motorists, pedestrians, and bicyclists, both young and old—must be considered in developing safety improvements. One of the Nation's challenges is to ensure that while implementing a safety improvement for one class of road user the safety of another is not compromised. Thus, rumble strips must be designed to allow safe use of road shoulders by bicyclists, and roundabouts must be designed to accommodate the expected level of pedestrian activity. The interdisciplinary approach of road safety audits can help greatly in this regard.

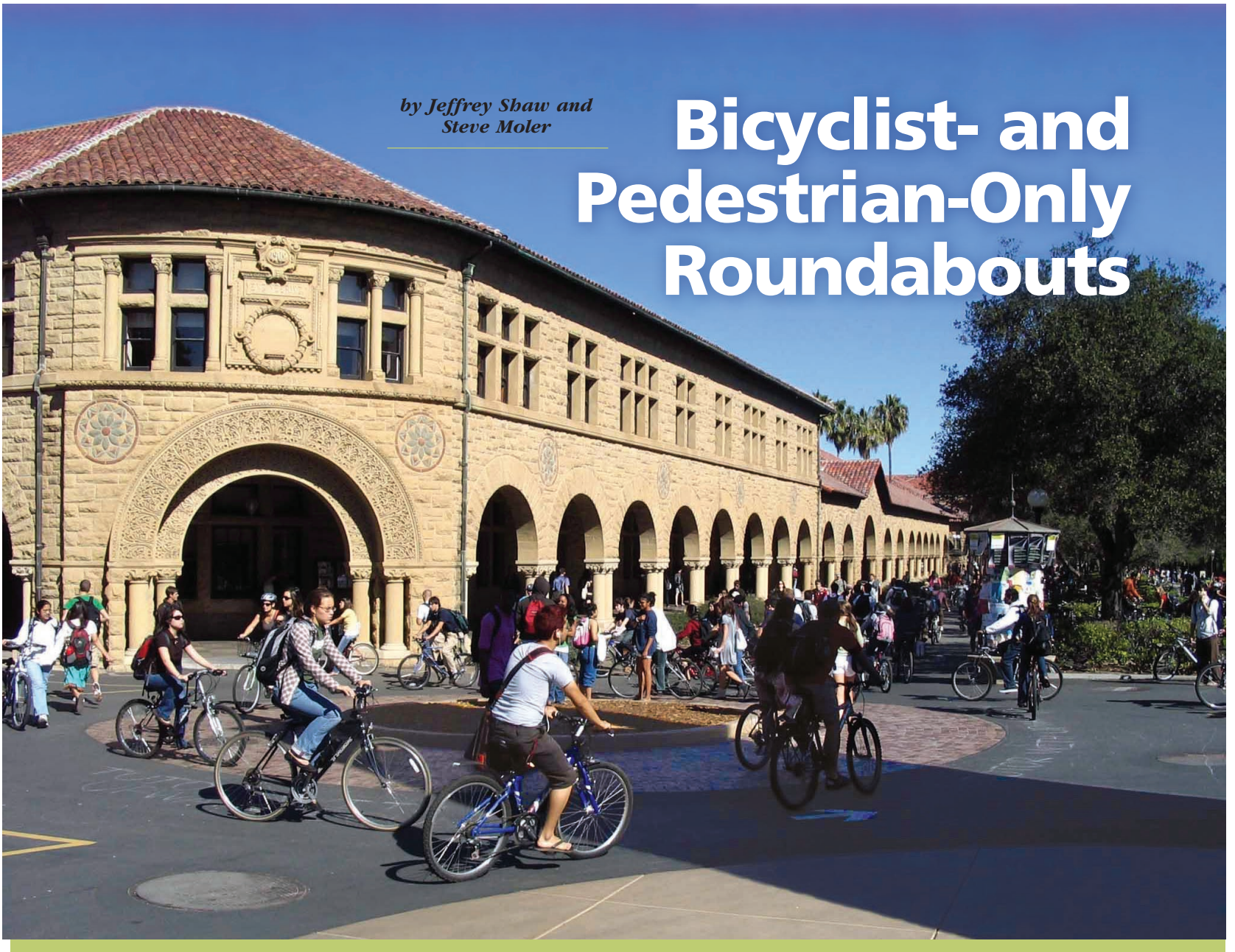
This issue of PUBLIC ROADS features an article, "The Sound of Safety," that describes research in Arizona on centerline rumble strips, which may reduce lane departure crashes. Another article, "Bicyclist- and Pedestrian-Only Roundabouts," discusses facilities dedicated solely to nonmotorized traffic for reducing injuries and fatalities.

Just as these countermeasures have moved from innovations to accepted practice, others have taken their place in the product development and deployment continuum. Features currently being developed, tested, and evaluated include activated curve warning signs, variable speed limits, and cooperative intersection collision avoidance systems. Someday these safety improvements will be commonplace, as the U.S. transportation community strives continually to improve the safety of America's highways.

David A. Nicol
Director, Office of Safety Design
Federal Highway Administration

by Jeffrey Shaw and Steve Moler

Bicyclist- and Pedestrian-Only Roundabouts



Facilities dedicated solely to nonmotorized traffic are an emerging development for improving mobility and reducing injury and fatality rates.

National crash data demonstrate the importance of minimizing conflicts between motorists, bicyclists, and pedestrians. During the past decade, traffic crashes killed between 600 and 800 bicyclists nationwide annually. In 2007, crashes killed 698 bicyclists and injured another 43,000. Pedestrians fare much worse: 4,654 died in crashes in 2007, according to the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System.

(Above) Stanford University constructed this roundabout in summer 2007 at the notorious bicycle-pedestrian crossroads known as the Intersection of Death. *Photo: Stanford University.*

The roundabout is becoming more popular at intersections on America's roadways, primarily because of its ability to improve safety and traffic flow, particularly in situations involving low and medium traffic. The Federal Highway Administration (FHWA) estimates that crews construct 150–250 new roundabouts each year in the United States. The typical modern roundabout is a shared-use facility, serving motor vehicles, bicyclists, and pedestrians.

But another type of roundabout is making an appearance in transportation infrastructure. Transportation agencies now are designing roundabouts dedicated to bicycles and pedestrians, and sometimes bicycles only, on shared-use paths. These paths serve bicyclists, walkers, joggers, skaters—virtually all nonvehicle traffic.

Shared-use paths and their associated roundabouts usually supplement onroad bicycle facilities such as bicycle lanes, paved shoulders, and bicycle routes. Shared-use paths typically are located alongside riverbanks, oceanfronts, canals,

abandoned or active railroad and utility rights-of-way, and limited-access freeways; on college and university campuses; and in parks and on connectors between parks. The roundabouts are particularly useful and effective when bicycle volumes are relatively high.

Transportation agencies are building bicycle-pedestrian roundabouts on shared-use paths for the same reasons they build vehicle roundabouts on roads: improved safety and traffic flow. Bicyclists, skaters, and other faster moving users enter a roundabout by first slowing down and yielding to those already there. Once inside, users move counterclockwise according to posted traffic control signs and directions. As with motor vehicle roundabouts, fewer conflicts occur on shared-use paths compared with traditional intersections.

"We're seeing transportation planners and safety engineers at the local level applying the same basic principles of the motor vehicle roundabout to the bike-pedestrian-only roundabout," says Patrick Hasson, team leader for the Safety and Highway Design Technical Service Team at FHWA's Resource Center in Olympia Fields, IL. "This is an effective way to take the success of one type of facility and apply it to another. This can only be a positive trend in helping improve safety and mobility on our path systems and college campuses."

A National Policy Is Born

Planning and constructing transportation facilities with bicycles and pedestrians in mind has become a national policy since enactment of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). In response to Section 1202 (b) of the Transportation Equity Act for the 21st Century (TEA-21) of 1998, the successor to ISTEA, USDOT released a policy statement including the following: "To varying extents, bicyclists and pedestrians will be present on all highway and transportation facilities where they are permitted and it is clearly the intent of TEA-21 that all new and improved transportation facilities be planned, designed, and constructed with this fact in mind."

The current surface transportation law, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005, now requires that bicycle and pedestrian needs be integrated into the overall transportation planning processes at the State and local levels.

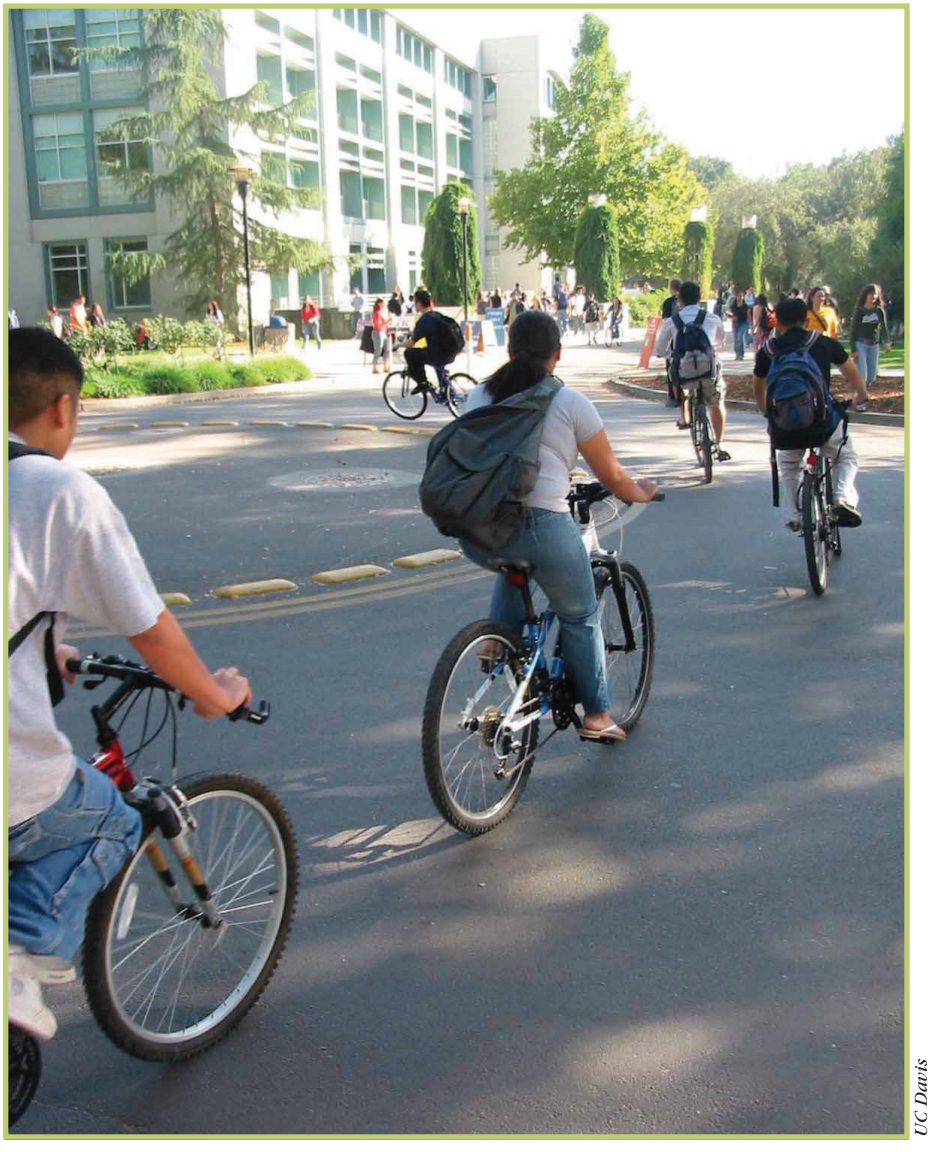
These Federal laws, combined with the public's increased awareness of the health, environmental, and cost benefits of walking and cycling, have increased demand for more and better facilities to accommodate bicycle and pedestrian interests safely. State and local governments have responded by constructing numerous efficient bicycle-pedestrian facilities.

Bicycle-Friendly Davis

That roundabouts are an increasingly popular and viable component of bicycle-pedestrian facilities in certain environments applies particularly to Davis, CA, a university town of about 64,000 people between Sacramento and the northeastern suburbs of the San Francisco Bay area.

Both the city and University of California, Davis (UC Davis), have been leaders in making transportation facilities accessible to pedestrians and bicyclists. Davis was the first community in the country to be named a platinum-level Bicycle Friendly Community by the League of American Bicyclists.

Davis has bicycle lanes on about 95 percent of its arterials and collectors. The city also has 27 different locations where motor vehicle traffic is separated from bicycles and



UC Davis

Students move counterclockwise through this roundabout at Shields Avenue and West Quad Way on the UC Davis campus in California.

Pioneers of the Bicycle-Pedestrian Roundabout

Asked to name a role model for building a bicycle- and pedestrian-friendly community, experts often point to the city of Davis, CA, and UC Davis. According to the League of American Bicyclists, Davis was one of the first U.S. cities to integrate the bicycle into its transportation infrastructure. And UC Davis was one of the first universities to make extensive use of shared-use bicycle and pedestrian roundabouts on campus to improve safety and mobility.

As the automobile hit full stride in the 1960s, Davis and its university were thinking differently. They began envisioning a multimodal community that included extensive walking and bicycling when neither mode was popular—decades before today's concerns about high fuel prices, congestion, and health-conscious living.

According to the paper "Fifty Years of Bicycle Policy in Davis, CA," by UC Davis's Ted Buehler and Susan Handy, after returning from a sabbatical in the Netherlands, Frank Child, a UC Davis economics professor, his family, and others formed a citizens' group that began meeting with city officials to advocate for bike lanes and other bicycle improvements. Shortly after a pro-bikeway slate of candidates was elected to the Davis City Council in April 1966, the city began building a bicycle trail system that quickly gained wide acceptance.

In fall 1967, Davis created the first official striped bike lanes in the United States. A short time later, UC Davis banned almost all motor vehicles from its campus roadway system. The university built a series of bike paths along the campus perimeter that channeled bicyclists into the center of campus. About six roundabouts were constructed on campus in the 1970s, and another six were built over the last 20 years.

Since the 1970s, the city and university bikeway systems have expanded steadily to their present size. Davis, with an area just under 26 square kilometers (10 square miles), now has about 80 kilometers (50 miles) of bike lanes and 84 kilometers (52 miles) of bike paths. More than 90 percent of all the collectors and arterial streets within the city have bike lanes or bike paths, or both. The city is known for experimenting with special bicycle facilities such as bike detectors (loop or video detectors that trigger a flashing warning light if a bike or vehicle is coming toward the intersection), signal heads, and bicycle-only roundabouts.

Davis's extensive trail system has led to widespread use. About 14 percent of all trips to and from work are made by bicycle. On campus, nearly half the university's 30,000 students, most of whom live off campus, ride a bike or walk as their primary mode of getting to and from class. About 1,800 faculty and staff, or about 20 percent of the total, also walk or bike to campus.

Davis's unofficial designation as the Bicycle Capital of the United States can be attributed largely to its physical, social, and political environment. In addition to a mild climate, flat terrain, and wide streets, Davis is "a closely defined and relatively self-sustained community," says David Takemoto-Weerts, UC Davis's bicycle program coordinator. Most city activity centers are within easy cycling range of the most remote households, making the bicycle a viable transportation mode for almost all trips.

But the most important factor, he says, is local attitudes. Davis has a relatively large, young, and healthy student population for which the bicycle is a natural transportation choice. Also, since the mid-1960s, city politicians and activists have helped create a bicycle culture in Davis by encouraging tolerance of all transportation modes. Even the city's official logo contains an image of a late-1800s bicycle.

"Bicycles plying the streets of Davis have become so commonplace that conflicts between cyclists and motorists are rare because so many residents use both modes extensively," Takemoto-Weerts says. "There's mutual understanding and respect for the needs and desires of both groups."

UC Davis

UC Davis banned all motor vehicles from its campus roadway system in the late 1960s. As a result, the university has converted some of its intersections, such as this one at Storer Mall and California Avenue, into bicycle and pedestrian roundabouts. Concrete bumpers and installed splitters, signs, and other devices help to keep traffic moving smoothly in the right direction.

pedestrian traffic using such structures as bridges, underpasses, and tunnels.

Over the past 10 years, the city has spent more than $14 million on bicycle projects, including bicycle-only roundabouts. UC Davis's extensive bicycle-pedestrian trail network features more than a dozen roundabouts at key locations throughout the campus. Several of these roundabouts, which date to the 1970s, were built primarily because of heavy bicyclist and pedestrian traffic during class change time at key intersections near large lecture halls. The remaining roundabouts were built at various times throughout the 1980s and 1990s due largely to the success of the earlier ones, according to David Takemoto-Weerts, UC Davis' bicycle program coordinator.

"When thousands of students get out of class at the same time, you get a very intense short-term rush hour lasting 10 minutes," says Takemoto-Weerts. "That's when problems occur. Roundabouts help minimize congestion at the busiest intersections."

UC Davis built its first roundabout at an intersection in front of what is known as 194 Chemistry, one of the largest lecture halls on campus. The university initially experimented with using old firehoses to construct an inner radius. Additional striping helped guide the hundreds of bicyclists and pedestrians safely and more efficiently through the congested intersection. The university later replaced the

firehoses with concrete bumpers, and installed splitters, signs, and other devices to keep traffic moving smoothly in the right direction.

"UC Davis officials just watched and things improved," Takemoto-Weerts says. "The university didn't do any formal studies, but you could just sit there and observe the improvements in traffic flow. It was pretty impressive."

Stanford's New Roundabouts

The successful use of roundabouts by UC Davis has prompted other colleges and universities to build roundabouts to improve safety and mobility. At Stanford University in Stanford, CA, with a student population of about 13,200, students told the university through a series of focus group discussions that certain campus intersections were dangerous, particularly during class changes. As a result of these discussions and other circumstances, Stanford recently installed two roundabouts to improve safety, traffic flow, and aesthetics. One of the roundabouts is at a crossroads known as the Intersection of Death, where pedestrians and bicyclists frequently experienced conflicts.

Bicyclists now are learning to travel counterclockwise around one roundabout and into a two-lane straightaway between the Barnum Center and Building 500 before being directed into the second roundabout. Ground-painted traffic signs help guide bicyclists properly through the roundabouts. New sidewalks separate pedestrians from the steady stream of bicycles through Stanford's most congested area. The roundabouts are part of a master plan to redesign the center of campus to make it safer and more attractive.

"The goal of the roundabouts is, first, to slow down students on bicycles and, second, to improve traffic flow," says Cathy Blake, associate director of Campus Planning and Design. "A third goal is to provide a refuge for pedestrians who want to get out of the traffic. Before the roundabouts were installed, people would go through these intersections full speed ahead during off-hours. During class change time, it could be almost gridlock."

Although the roundabouts had been in Stanford's plan for about 2 years, the university's marching band tested the idea in fall 2006. The band built a roundabout in front of Stanford's landmark clock tower to help improve traffic flow during the week of the big game with crosstown football rival the University of California, Berkeley. Band members adorned the circle with a sculpture and decorations.

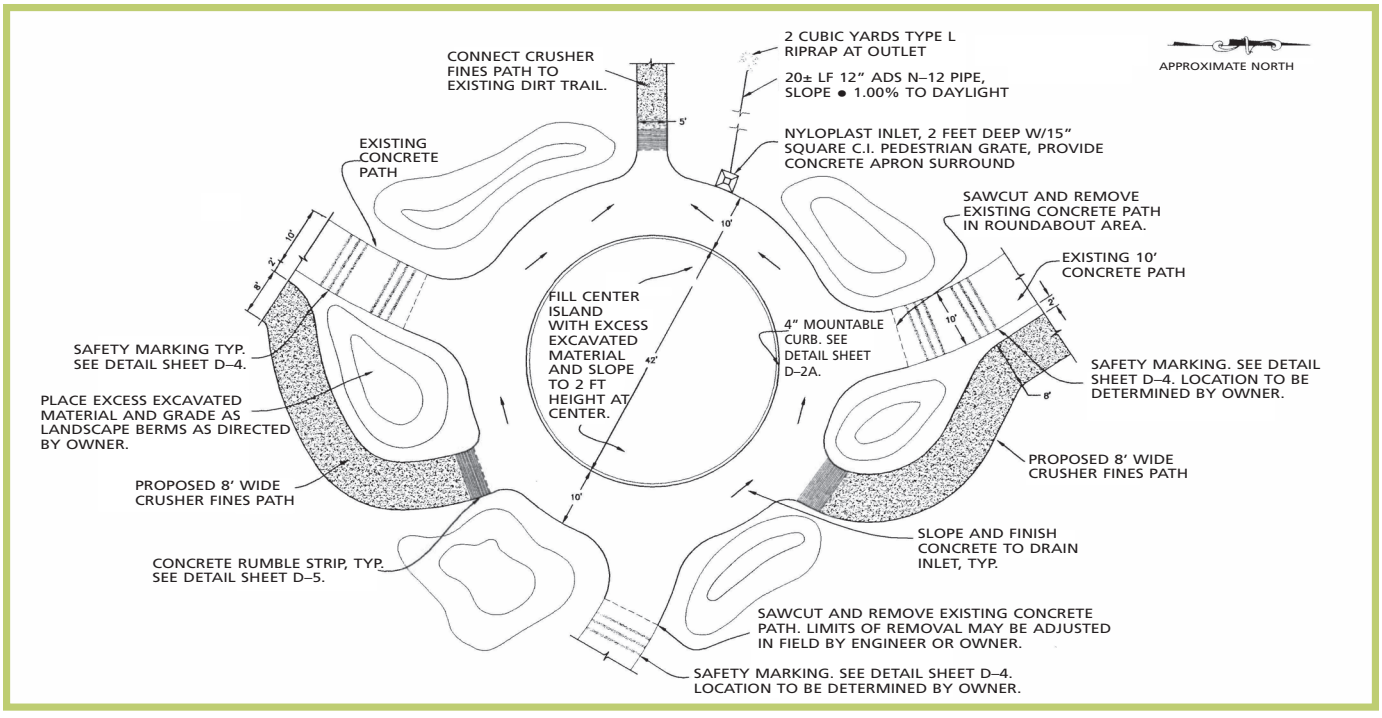
The makeshift roundabout seemed to improve traffic flow, says Carolyn Helmke, who was Stanford's bicycle program coordinator until

Bicyclists navigate Stanford's Intersection of Death on their way to and from classes.

Stanford University

Stanford University

During a typical class change rush period, Stanford University students head toward the Intersection of Death, where a roundabout (not shown) was constructed in summer 2007 to improve safety and mobility on this busy pedestrian-bicycle thoroughfare. Beyond the busy intersection is a short straightaway and a second newly constructed roundabout at White Plaza.



This engineer's schematic shows the Lee Gulch/South Platte River roundabout on the Mary Carter Greenway trail south of Denver, CO. The crushed gravel (pedestrian) and concrete (bicyclist) trails run separately yet parallel until they merge at the roundabout. Once the bicyclists slow down as they approach the roundabout, all trail users share the roundabout. *Source: WHPacific, Inc.*

June 2008. Although plans for the two roundabouts already were underway, the band's effort gave the proposed projects a psychological boost and helped call attention to the need for mitigating bicycle and pedestrian conflicts on campus, she says.

Roundabouts on Shared-Use Paths

One reason for the increased interest in roundabouts is the desire of transportation officials to separate bicyclists from pedestrians on shared-use paths and trail systems. This was the case at the South Suburban Park and Recreation District outside Denver, CO, where officials acted after a deadly crash in 2004.

The South Platte River Greenway is a 56-kilometer (35-mile) trail system south of downtown Denver. One of the trails, the Mary Carter Greenway, consists of a 3-meter (10-foot)-wide concrete pathway that accommodates up to 700,000 walkers, joggers, roller skaters, and bicyclists annually. But after its completion in the 1980s, the trail quickly filled with a multitude of users ranging from families with toddlers in strollers to high-speed cyclists on training rides.

"The pedestrians felt intimidated by the cyclists, and the cyclists got frustrated with pedestrians sometimes walking two or three abreast and blocking the trail," says Bill Woodcock, manager of planning and development with the South Suburban Park and Recreation District in Littleton, CO, which administers the trail system. "This crowding led to conflicts, and in some cases diminished enjoyment for our users. We needed to do something about safety and bring the trail back to the people."

A fatal head-on collision involving two bicyclists on the greenway in 2004 prompted trail management, law enforcement, and safety experts to convene a forum to address ways to reduce conflicts and improve overall safety. Some immediate solutions included painting a centerline along the entire length of the path, posting a speed limit of 24 kilometers per hour, km/h (15 miles per hour, mi/h), and stepping up enforcement. Police have used radar to clock speeding cyclists and, in some cases, issued citations. Additional speed limit signs also have been posted at key locations.

A longer term remedy involved constructing a crushed-stone, pedestrian-only path parallel to the paved trail. Those two parallel facilities, like all South Suburban Park trails, were constructed to accommodate people with disabilities in accordance with the Americans with Disabilities Act. But trail officials still needed to slow bicyclists down and manage traffic at key junctions where pedestrians and bicyclists shared the pathway.

Near the Carson Nature Center, children on nature hikes would come into conflict with high-speed cyclists. The center also has a parking area where people unload their bicycles and access the main trail, says John Pflaum, a senior project engineer with WHPacific, Inc., a Denver-based engineering consulting firm working with the recreation district. "We had to figure out how to sort out the bicycle and pedestrian traffic. The roundabout proved to be the best solution."

The district built the roundabouts at two of its most congested intersections: one near the Carson Nature Center and the other at the junction of the Lee Gulch and South Platte River trails. Both roundabouts have nearly identical designs, including a 3-meter (10-foot)-wide concrete path surrounding a 13-meter (42-foot)-diameter landscaped center island.

The island has a 10-centimeter (4-inch) mountable curb, which, combined with the landscaping, discourages users from cutting through the inner circle. Trail system rangers say they are pleased with the dual trail and roundabouts, which they believe have led to fewer crashes. "The roundabouts have definitely slowed the bikes down," Woodcock says.

The recreation district is planning to construct another roundabout and bicycle bridge near the city of Englewood's golf course to separate golf carts, bicycles, and pedestrians.

UCSB Adopts Roundabouts

The University of California, Santa Barbara (UCSB), with a student population of about 20,000, also has adopted the roundabout approach for separating bicyclists and pedestrians whenever possible to improve safety and mobility. About 14,000 students, staff, and faculty commute to campus by bicycle each day. The university responded by constructing an extensive shared-use path and trail system that integrates with the city and county's path network.

UCSB's bicycle-pedestrian path system contains both shared and separated paths, but the emphasis in recent years has shifted to suburban solutions that completely separate bicycle and pedestrian paths for safety reasons, says Campus Planning and Design Director Tye Simpson. The university's path system includes six campus roundabouts and four grade separations that help minimize conflicts between pedestrians and bicyclists. These facilities include refuge islands so pedestrians have to wait only long enough to cross one lane of bustling bicycle traffic on the way to their next classes.

"Starting in the 1980s, our bicycle traffic volume skyrocketed," Simpson says. "The recreational approach, where everyone shared the pathways, wasn't working. So we started constructing bike-only routes so bicyclists didn't conflict with pedestrian traffic. Some of our bike routes are like freeways. The roundabouts were our way to deal with bike and pedestrian conflicts at intersections."

Simpson says the challenge now is sharing routes because in a more urban context there is not enough space for every transportation mode to have its own exclusive facility.

Roundabouts at Critical Intersections

The municipality of Anchorage, AK, is in the process of constructing two roundabouts as part of a major upgrade and expansion of its Chester Creek Trail system. City officials observed that rider inattentiveness and speeding created potential safety problems at certain intersections. Roundabouts, they determined, would help keep traffic flowing and minimize conflicts between faster and slower riders. One of the roundabouts will be at a critical intersection about halfway between a University of Alaska Anchorage (UAA) residential complex and the Alaska Native Medical Center, near the shores of University Lake. The other roundabout will be farther north, at a connector to the Northern Lights Trail north of UAA and Alaska Pacific University. The Alaska Department of Transportation and Public Facilities is constructing the roundabouts for Anchorage using SAFETEA-LU funds.

"We included the two roundabouts in the design because we wanted to keep bike speeds down at those locations and keep people traveling on the correct trail," says Lori Schanche, coordinator of nonmotorized transportation for Anchorage. "The location of the roundabouts coincides with intersections of minor spur trails, and since we were not able to obtain additional right-of-way, we wanted to keep the main trail flow obvious."

The roundabout designs are based on a previous bicycle-pedestrian roundabout built in the mid-1990s along the Campbell Creek Greenway near C Street. That roundabout, which had to be torn out when two adjoining trail spurs were removed, was considered by Anchorage to be a success. "We didn't have any incidents or issues with that roundabout," says Schanche.

Another application of a roundabout at a critical intersection is in the Cape Cod area of Massachusetts. The Massachusetts Department of Conservation and Recreation (DCR) constructed the Cape Cod Rail Trail in the 1970s along an abandoned railroad right-of-way. Extensive upgrades since the early 1990s include a tunnel and two bridges over Highway 6. DCR also built an extension from Harwich to Chatham along another former railroad right-of-way.

DCR installed a bicycle-pedestrian roundabout in 1998 at the intersection of the rail trail and the new Harwich-Chatham extension to slow bicyclists and keep traffic flowing

South Suburban Park and Recreation District

The South Suburban Park and Recreation District recently built a roundabout at the junction of the Lee Gulch and South Platte River trails, shown here. Not visible on the right side of the photo is the Lee Gulch Trail intersecting the South Platte River Trail. Notice the worn "shortcut" path through the roundabout inner circle. The district later placed several large boulders and additional landscaping inside the roundabout circle to discourage users from taking shortcuts through the inner circle.

Libby Montero

This roundabout on a recreational trail in The Villages, FL, is open to golf carts, bicycles, and pedestrians, sometimes creating potential near-miss conflicts as shown here. The Florida retirement community of 72,000 residents has more than 145 kilometers (90 miles) of transportation trails, including permitted travel for golf carts, bicyclists, and pedestrians on residential streets, providing access to recreational, commercial, and professional services and saving an untold number of car trips each year.

in the right direction. The roundabout's relatively large grassy inner circle, measuring about 30 meters (100 feet) in diameter, is equipped with such amenities as bicycle parking, benches, picnic tables, and trash cans.

Designing the Bicycle-Pedestrian Roundabout

If transportation planners opt for a bicycle-pedestrian-only roundabout, what guidelines should they apply in the facility's design, construction, and operation? Actually, there are no authoritative sources on the topic, which provides an opportunity for bicycle and pedestrian transportation specialists to work with one another and organizations such as the American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), and Transportation Research Board (TRB) to develop uniform guidelines.

In the absence of definitive guidelines, some roundabout designers use the AASHTO *Guide for the Development of Bicycle Facilities* as a reference on how to proceed with geometric layout, signing, marking conventions, and other critical details. The design guidelines for shared-use paths offer general suggestions that transportation planners can apply to bicycle and pedestrian roundabouts. For example, a minimum width of 1.8 meters (6.0 feet) is recommended for a one-direction shared-use path, useful information for ensuring that entry and circulating lane widths are not scaled down too severely.

But the criteria dealing with horizontal alignment, curvature, and superelevation are mostly relevant to continuous segments of paths and trails, not necessarily intersections. Although planners may glean helpful information from the AASHTO guide, it is currently up to each individual designer to relate the more general criteria to the detailed design necessary for a bicycle and pedestrian roundabout.

One option might be to apply standard engineering principles for traditional motor vehicle roundabouts and then adjust the designs based on the smaller size and slower speeds of bicycles. Another would be to perform tests involving pedestrians and bike users at roundabouts of different designs to help develop standards. A helpful starting point for bicycle- and pedestrian-only design is to recall the key principles of modern roundabout design: speed through the roundabout is reduced, entry geometry provides adequate deflection to aid in speed reduction, circulation has an intuitive orientation (to favor the counterclockwise for example), and entering users must yield the right-of-way to users already circulating in the roundabout.

The first principle, speed reduction, is likely to have the most profound influence on the overall size of a bicycle-pedestrian roundabout due to the direct relationship between speed and curvature. According to FHWA's *Roundabouts: An Informational Guide* (FHWA-RD-00-67), achieving a 30–50 percent speed reduction of vehicles through the roundabout compared to approach speeds is desirable. The same would likely hold true with bicycle-pedestrian roundabouts. The reduction in speed at the roundabout approach could potentially improve safety.

For a shared-use facility with a design speed of 32 km/h (20 mi/h) (per the AASHTO guide), this yields a circulating speed range of about 16 to 22 km/h (10 to 14 mi/h). Even at speeds this low, bicycles remain stable and the entry and circulating curve geometries are kept to reasonable and minimal scales. These geometries enable a bicycle-only roundabout to occupy a much smaller footprint compared to a motor vehicle facility. And, as with vehicle roundabouts, this significant reduction in speed speaks to better safety performance—for all users.

Additional design detail considerations might include use of sloped or mountable curbing for the raised features of a roundabout, such as splitter islands and a central island, avoiding the potential tripping hazard of a raised, 15-centimeter (6-inch) curb. Also, designers should choose the location and height of vegetation and signing carefully, because low-hanging features when placed near the traveled edge of the path can interrupt sight lines and might prove dangerous to bicyclists and pedestrians. Furthermore, facilities must meet accessibility requirements.

Michael Moule, president of Livable Streets Inc. of Tampa, FL, a bicycle and pedestrian facilities consulting firm, says the following about designing a roundabout on shared-use paths: "I would start by

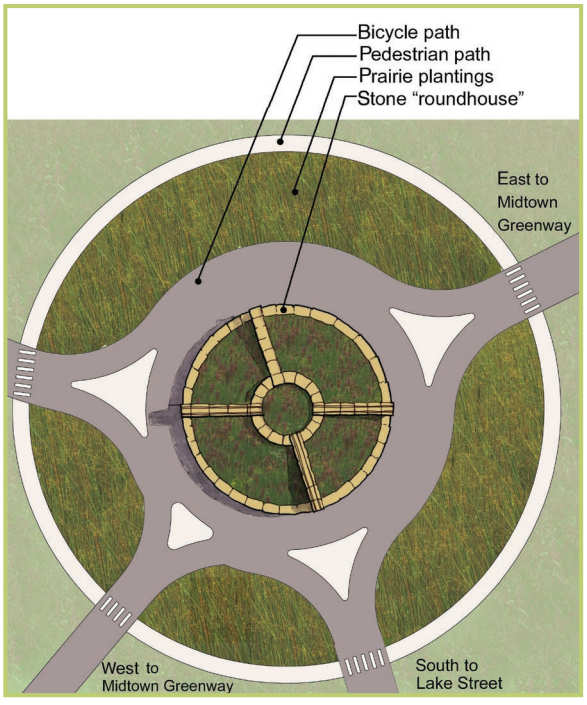
not building it too small and otherwise follow good engineering and roundabout design principles. I've seen several proposals for little circles on paths with about 20-foot [6.1-meter] outside diameters. I think this in general is too small. It's not large enough to allow users to circulate appropriately, and the resulting 5-foot [1.5-meter]-diameter center island becomes more of a fixed-object hazard than anything else."

The roundabouts at UCSB have outside diameters of about 19.8 meters (65.0 feet), Moule says. "That's about right. If the circle is too large, say, over 100-foot [30-meter] outside diameter, users won't want to go all the way around and will tend to take shortcuts when making left turns."

The city of Minneapolis learned what happens when a bicycle roundabout is designed too large. In 2007, the city sought to construct the State's first bicycle roundabout at the intersection of the Midtown Greenway and Hiawatha Trail, a high-traffic location with up to 4,000 users per day. The roundabout was one of several bicycle and walking trail projects the city wanted to build as part of FHWA's Nonmotorized Transportation Pilot Program.

When it came time to design the roundabout, Minneapolis had to "fly by the seat of its pants," says Don Pflaum, the city's bicycle coordinator and a transportation planner. "We had to look at how to accommodate both bicyclists and pedestrians, how to deal with the high traffic volumes, whether to separate the bicyclists from the pedestrians, how to slow down the bicyclists, what the design speeds should be—all of that. There definitely need to be some national guidelines on this."

Minneapolis ultimately came up with a preliminary design that included a shared bicycle-pedestrian facility with a 4-meter (13-foot)-wide path, which was divided into a 2.1-meter (7.0-foot) lane for bikes and 1.8-meter (6.0-foot) lane for pedestrians. The roundabout also featured a 30-meter (100-foot)-diameter inner circle, which the city and public agreed was too large and too costly.



This diagram depicts a proposed bicycle-pedestrian roundabout that Minneapolis wanted to construct at the high-traffic intersection of the Midtown Greenway and Hiawatha Trail. The project was cancelled after the roundabout was deemed too large and too costly. *Photo: City of Minneapolis.*

"When we got to preliminary design and took the proposal out to the public for comment, we realized the roundabout was larger than we wanted for our budget," says Jack Yuzna, a principal with the Minneapolis Department of Public Works who worked on the project. "The larger-than-expected diameter increased the cost almost four times, so due to budgetary constraints we've decided not to move forward with the roundabout at this time."

A New Tool in the Box

Shared-use paths and trail systems used for both transportation and recreation continue to grow in number and miles. As these facilities expand, the potential for them to intersect increases, along with the potential for intersection-related crashes.

Sources mentioned in this article offer some guidance to designers, but no authoritative guidance document exists that designers can turn to for explicit details on how to provide appropriately sized roundabouts for bicyclists and pedestrians only. And although many bicycle- and pedestrian-only roundabouts have been built, the risk of not moving forward with national guidance could lead to missed opportunities, as in Minneapolis.

Given the active involvement of ITE, TRB, and others in implementing traditional vehicle roundabouts, perhaps the time is right to convene an effort to produce guidelines for bicycle-pedestrian-only roundabouts by bringing together the necessary expertise from around the Nation: roundabout designers, bicycle and pedestrian specialists, and trail and path planners. Whether on a college campus or other shared-use paths, the roundabout is an option that might minimize bicyclist and pedestrian conflicts and improve overall safety and mobility.

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Steve Moler is a public affairs specialist at FHWA's Resource Center in San Francisco. He has been with FHWA for 7 years, assisting the agency's field offices and partners with media relations, public relations, and public involvement communications. He has a bachelor's degree in journalism from the University of Colorado at Boulder.

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Editor's note: Because California law only requires bicyclists under the age of 18 to wear helmets, some of the bicyclists shown in this article are not wearing helmets. For safety, however, FHWA and NHTSA recommend that all cyclists wear proper helmets.

The Sound of Safety

Arizona's findings point to centerline rumble strips for reducing lane departure crashes.

by Kobinoor Kar and Richard S. Weeks

Many rural two-lane roadways lack medians, barriers, or other physical measures to separate the travel lanes. As a result, a distinct potential exists for vehicles to cross centerlines, possibly leading to sideswiping or striking oncoming vehicles head-on. According to an Insurance Institute for Highway Safety (IIHS) study, *Crash Reduction Following Installation of Centerline Rumble Strips on Rural Two-Lane Roads*, these types of centerline crossover crashes account for about 20 percent of fatal crashes on two-lane rural roads.

A promising remedy is emerging, however. A growing number of States are using centerline rumble strips (CLRSs) to warn drivers against

crossing over into opposing traffic. For example, the Washington State Department of Transportation (WSDOT) has installed about 1,545 kilometers (960 miles) of CLRSs in various locations. Of the 960 highway miles, WSDOT engineers have conducted preliminary evaluations of 834 kilometers (518 miles) that have been in place 6 months or longer. Preliminary results indicate a 28 percent reduction in all fatal and serious injury collisions, 26 percent reduction in all cross-centerline collisions, and 50 percent reduction in fatal and serious injuries resulting from cross-centerline collisions. According to WSDOT's *The Gray Notebook*, "It is important to note that these reductions may not be entirely attributable to rumble strips, as other safety improvements may have been implemented under the same contract that installed the rumble strips."

Other IIHS research suggests that CLRSs can reduce the rate of injury collisions on two-lane roads by 15 percent, with similar benefits in terms of fatalities.

CLRSs offer corollary benefits as well. State departments of transportation (DOTs) can install the strips fairly inexpensively at about $2,000 per mile, and they can coordinate the installation with the paving cycle. CLRSs also require minimal maintenance. According to WSDOT, this low cost provides CLRSs with a benefit-cost ratio of about 60:1 based on nationwide average costs.

Today, at least 23 States and 2 Provinces in Canada use CLRSs: Arizona, California, Colorado, Delaware, Florida, Illinois, Indiana, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New York, North Carolina, Oregon, Pennsylvania, South Dakota, Texas, Utah, Washington, and Wyoming; and Alberta and Nova Scotia.

"By installing 5,700 miles [9,173 kilometers] of centerline rumble strips and 1,200 miles [1,931 kilometers] of shoulder rumble strips between 2008 and 2010, the Michigan Department of Transportation [MDOT] is systematically—and cost effectively—upgrading safety on our high-speed, nonfreeway rural road system," says Jill Morena, pavement marking and rumble strip program engineer at MDOT. "This is a systematic treatment for a systemic problem."

In Arizona, centerline crossover crashes result in a significant percentage of serious injuries and fatalities on its rural, high-speed, two-way, two-lane roads. Between 2000 and 2005, these crashes comprised 5 percent of all incidents on Arizona's 6,437 kilometers (4,000 miles) of rural highways but accounted for 26 percent of fatal crashes.

(Left) ADOT installed this centerline rumble strip on State Route 64 east of the Grand Canyon as one of the segments evaluated in a study on the effectiveness of this technique in reducing head-on and crossover sideswipe crashes. *Photo: Kohinoor Kar, ADOT.*

Other State and Provincial Efforts Using Centerline Rumble Strips

Rumble strips to prevent lane departure crashes on rural, undivided highways are increasingly popular among States and Canadian Provinces. The following is a sampling of how some States and Provinces are using CLRSs, as found in a literature review performed by ADOT researchers.

California analyzed milled CLRSs at no-passing zones. An evaluation of a 37-kilometer (23-mile) segment found a reduction in crashes. During the before period, crashes occurred at a rate of 4.5 per month; during the after period, 1.9 crashes occurred per month. The State uses a pattern of 16.5-centimeter (6.5-inch) by 40.6-centimeter (16-inch) by 1.3-centimeter (0.5-inch) grooves, spaced at 61 centimeters (24 inches).

Colorado uses milled CLRSs at locations with high crash histories in both passing and no-passing zones. Through a research project, the State found a 34 percent reduction in head-on crashes and 36 percent reduction in sideswipe opposite direction crashes. Colorado's experience also has shown that CLRSs have no harmful or damaging effect on pavement life. The State uses a pattern of 13-centimeter (5-inch)-long by 30.5-centimeter (12-inch)-wide by 0.95-centimeter (0.38-inch)-deep grooves, spaced 30.5 centimeters (12 inches) on center, based on another research project.

Delaware evaluated milled CLRS installations using 41-centimeter (16-inch)-wide rumble strips spaced at 30.5 centimeters (12 inches). The State found a 95 percent reduction in head-on crashes based on a before-and-after study, and concluded that effectiveness does not decrease over time. The State did find that noise issues for nearby residents would need to be addressed.

Kansas evaluated the effectiveness of two milled CLRS patterns: one using 16.5-centimeter (6.5-inch) by 30.5-centimeter (12-inch) by 1.3-centimeter (0.5-inch) grooves spaced at 30.5 centimeters (12 inches), and the other using the same groove pattern spaced at 30.5 centimeters (12 inches) and 61 centimeters (24 inches), alternately. Based on the subjective opinions of 247 motorists, the continuous pattern was slightly more effective. Milled centerline rumble strips were found to be a cost-effective measure to reduce head-on crashes.

Massachusetts uses CLRSs at no-passing zones only. The pattern is 16.5-centimeter (6.5-inch) by 45.7-centimeter (18-inch) by 1.3-centimeter (0.5-inch) grooves spaced at 30.5 centimeters (12 inches).

Minnesota evaluated milled CLRSs on 402 kilometers (250 miles) of roadways to ascertain the effects on pavement life, accumulated ice, and motorcycles. The installations were in areas with minimum 80-kilometer (50-mile)-per-hour posted speed limits and head-on crash histories. The State identified noise as an issue based on proximity to residences. Focus groups reported rumble strips were helpful in snow and reduced visibility.

New York plans to place milled CLRSs at two-way no-passing zones (double yellow) only where justified by crash history.

Oregon uses CLRSs at no-passing zones. The State uses a pattern of 17.8-centimeter (7-inch) by 40.6-centimeter (16-inch) by 1.6-centimeter (0.63-inch) grooves spaced at 30.5 centimeters (12 inches). Oregon reports CLRSs as a generally positive experience.

Pennsylvania uses CLRSs at no-passing zones on roads based on road type and average annual daily traffic. The pattern is 17.8-centimeter (7-inch) by 35.6-centimeter (14-inch), 40.6-centimeter (16-inch), or 45.7-centimeter (18-inch) by 1.3-centimeter (0.5-inch) grooves spaced at 61 centimeters (24 inches) and 121.9 centimeters (48 inches). The State has found no adverse effect on motorcycles. Bicycles were not included in this study.

Washington has found no adverse effect on motorcycles. The pattern is 17.8-centimeter (7-inch) by 30.5-centimeter (12-inch) by 1.3-centimeter (0.5-inch) grooves spaced at 30.5 centimeters (12 inches). The reduction in opposite direction crossover crashes was not statistically significant.

Alberta uses a pattern of 16.5-centimeter (6.5-inch) by 30.5-centimeter (12-inch) by 1.3-centimeter (0.5-inch) grooves spaced at 30.5 centimeters (12 inches) for its CLRSs. The Province has found no adverse effect on motorcycles.

ADOT

ADOT installed this milled CLRS at the approach to a curve on a rural highway in northern Arizona.

To enhance safety, in 2002 the Arizona Department of Transportation (ADOT) began pilot installations of CLRSs on several stretches of rural highways in northern Arizona. ADOT researchers recently evaluated crash data from before and after the installations to determine the effectiveness of CLRSs in mitigating centerline crossover crashes. The results of this ADOT study, "Safety Enhancement Evaluation of Ground-In Centerline Rumble Strips," suggest that CLRSs can be a cost-effective solution to reduce crashes on rural roads. Further, ADOT's experiences, observations, and lessons learned could help other agencies that are considering CLRS installations within their own jurisdictions.

The Arizona Situation

One element of the Arizona Strategic Highway Safety Plan focuses on reducing fatal and serious injury crashes resulting from roadway departures. ADOT already completed programs to install milled shoulder rumble strips on all divided State highways and other qualifying highways to address roadway departure crashes involving fatigued and impaired drivers. According to the Federal Highway Administration, milled rumble strips are popular in many States because they are easy to implement on new or existing asphalt and portland cement concrete pavements and shoulders; they have little or no effect on the integrity of the pavement structure; and they produce greater noise and vibration than rolled or formed rumble strips.

Like other States, Arizona then began considering applying that success to addressing centerline crossover crashes—both opposite direction sideswipes and head-on collisions. "We were experiencing a high number of head-on collisions between Flagstaff and Page on Route U.S. 89," says ADOT Flagstaff District Engineer John Harper. "We were trying to find ways to reduce these types of crashes."

In 1998, the district installed CLRSs on about 40 kilometers (25 miles) of U.S. 89, a two-lane, two-way, rural highway in northern Arizona. Although the department did not produce a formal report documenting the findings, anecdotal

Centerline Rumble Strip Study Test Sites

CENTERLINE RUMBLE STRIP INSTALLED	SITE NUMBER	ROUTE	BEGIN MILEPOST	END MILEPOST	PAVED SHOULDER WIDTH	POSTED SPEED LIMIT	PERCENT AVAILABLE PASSING	AADT*	CENTERLINE RUMBLE STRIPS	SHOULDER RUMBLE STRIPS	DATE COMPLETED	COMMENTS
	1	SR64	267.97	270.27	8	65 MPH	63%	2,600	11,827	NONE	10/7/2002	
	2	SR64	270.27	276.16	8	65 MPH	91%	2,600	30,624	EXISTING	10/7/2002	Shoulder rumble strips installed prior to 9-1-99
	3	SR64	288.40	295.83	8	65 MPH	75%	2,600	35,693	EXISTING	10/7/2002	Shoulder rumble strips installed prior to 9-1-99
	4	US89	441.88	458.00	8	65 MPH	51%	14,000	79,728	EXISTING	10/30/2002	Shoulder rumble strips installed prior to 9-1-99
	5	US89	528.10	531.20	5	65 MPH	62%	3,000	15,551	EXISTING	10/30/2002	Shoulder rumble strips installed prior to 9-1-99. Centerline rumble strips installed as *Extra Work Order.*
	6	US89	531.20	546.80	5	65 MPH	64%	3,000	79,253	EXISTING	10/30/2002	Shoulder rumble strips installed prior to 9-1-99
	7	US89	551.50	557.00	5	65 MPH	53%	4,400	27,878	EXISTING	10/30/2002	Shoulder rumble strips installed prior to 9-1-99
	8	SR389	27.00	32.04	5	50 MPH	80%	1,200	24,869	EXISTING	9/30/2002	Shoulder rumble strips installed prior to 9-1-99
	9	US89	458.00	470.80	8	65 MPH	44%	6,900	60,134	13,800	10/30/2002	
	10	US89	495.00	503.80	8	65 MPH	63%	3,900	43,993	7,800	10/30/2002	
	11	US89	503.80	524.80	8	65 MPH	75%	3,900	104,804	7,800	10/30/2002	Centerline and shoulder rumble strips installed as *Extra Work Order.*
	12	US160	322.70	331.00	5	65 MPH	94%	3,300	41,256	6,600	10/4/2002	Centerline and shoulder rumble strips installed as *Extra Work Order.*
	13	US160	331.00	341.00	5	65 MPH	96%	3,300	51,691	6,600	10/4/2002	
	14	SR389	0.00	27.00	5	65 MPH	86%	800	138,864	1,600	9/30/2002	

**AADT = average annual daily traffic*

Study sites were on high-speed, low-volume, rural roads with a high percentage of available passing opportunities.
Source: ADOT.

observations were positive and supported the need for a formal study.

A review of research and evaluations by other States formed the basis for selecting a groove pattern that would generate an effective tactile and audible signal warning drivers of imminent crossovers. In addition to studying the safety benefits of CLRSs, ADOT set out to evaluate other issues including maintenance, objectionable sound, two-wheel vehicle control, constructability, driver confusion, and effectiveness in inclement weather.

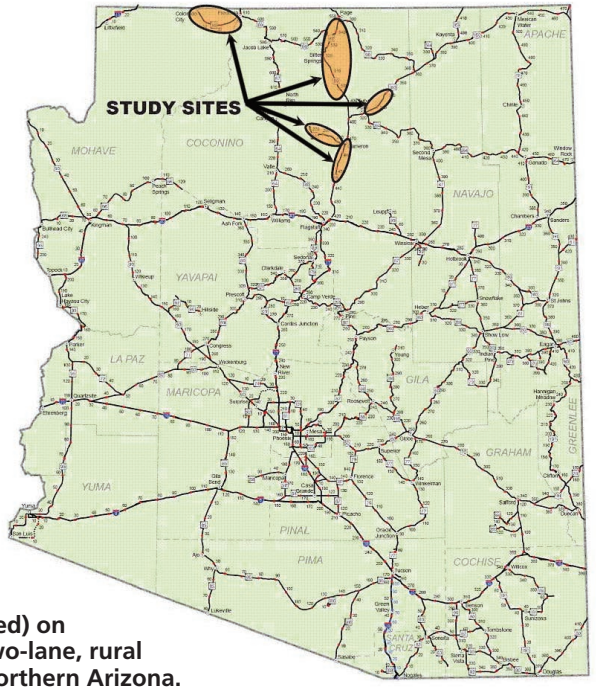
Study Location

In 2001, ADOT selected 14 highway sections for the study. These segments were typical low-volume, high-speed, two-lane, rural State highways in northern Arizona: State Route (SR) 64, SR 389, and U.S. 160, in addition to U.S. 89. The study sites were all located in the high desert at elevations of 1,524–1,829 meters (5,000–6,000 feet), where freezing temperatures occur in the winter along with substantial accumulations of snow and ice.

Unlike some studies conducted by other States, ADOT did not base its site selection on crash history. Instead, ADOT's goal was to evaluate the performance of CLRSs in mitigating centerline crossover crashes involving inattentive and impaired drivers on a statewide basis, rather than for limited application at site-specific locations with crash histories. This broad-based approach is consistent with ADOT's aggressive strategy to apply shoulder rumble strips statewide to address roadway departure crashes.

In 2002, ADOT installed CLRSs on 239 kilometers (149 miles) of the roadways identified in 2001. Specifically, the Flagstaff District installed CLRSs on 98 kilometers (61 miles) of highways that already had shoulder rumble strips. The department also installed both centerline and shoulder rumble strips on 142 kilometers (88 miles) of highways that previously had no rumble strips.

Arizona's CLRS Study Sites



ADOT

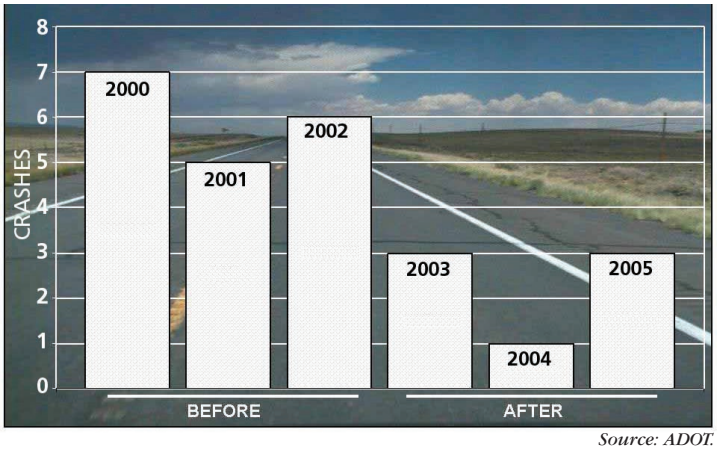
ADOT studied five sites (circled) on high-speed, two-lane, rural highways in northern Arizona.

Summary of Fatal/Serious Injury Crashes

	SITE NUMBER	ROUTE	BEGIN MILEPOST	END MILEPOST	BEFORE PERIOD				AFTER PERIOD			
					AADT	Head-on + Sideswipe Opposite	All Other	TOTAL	AADT	Head-on + Sideswipe Opposite	All Other	TOTAL
CENTERLINE RUMBLE STRIP INSTALLED	1	SR64	267.97	270.27	2,600			0	2,900			0
	2	SR64	270.27	276.16	2,600			0	2,900		2	2
	3	SR64	288.40	295.83	2,600	1		1	2,900	1	1	2
	4	US89	441.88	458.00	14,000	6	5	11	15,400	1	6	7
	5	US89	528.10	531.20	3,000		1	1	3,100		1	1
	6	US89	531.20	546.80	3,000	5	3	8	3,100	2	4	6
	7	US89	551.50	557.00	4,400	2		2	3,800	1		1
	8	SR389	27.00	32.04	1,200		1	1	2,600		1	1
	9	US89	458.00	470.80	6,900	2	9	11	8,100		2	2
	10	US89	495.00	503.80	3,900		1	1	4,300	1	1	2
	11	US89	503.80	524.80	3,900		5	5	4,300	1	5	6
	12	US160	322.70	331.00	3,300			1	4,000			0
	13	US160	331.00	341.00	3,300	1	1	1	4,000			0
	14	SR389	0.00	27.00	800	1	6	7	2,600		2	2

At the 14 study sites, the centerline crossover crashes accounted for 36 percent of the total fatal and serious injury crashes occurring during the before period and 22 percent in the after period. *Source: ADOT.*

Fatal and Serious Injury Centerline Crossover Crashes



Source: ADOT.

ADOT researchers determined that the number of fatal and serious injury crashes decreased by 61 percent after CLRSs were installed (comparing 3 years before with 3 years after installation).

The roadways included principal arterials, minor arterials, and minor collectors. All the roadways had two 3.7-meter (12-foot) lanes and either 1.5-meter (5-foot)-wide or 2.4-meter (8-foot)-wide paved shoulders, and were located in flat or gently rolling terrain. All but one segment carry low volumes of traffic. The rumble strip pattern used in the study was based on the standard pattern in use at that time for milled edge-line rumble strips.

Crash Analysis

ADOT researchers evaluated data from the roadways for the 3 years before (2000–2002) and 3 years after (2003–2005) installation to determine the effectiveness of CLRSs in reducing centerline crossover crashes.

The study revealed that centerline crossover crashes accounted for 36 percent of the total fatal and serious injury crashes occurring in 2000–2002 and 22 percent in 2003–2005. CLRSs helped cut the number of serious injury and fatal head-on and opposite direction sideswipe crashes from 18 in the "before" period to 7 in the "after" period.

In the before period, 12 of the 18 crashes occurred on tangent segments, 3 occurred on 2-degree curves, 1 on a 4-degree curve, and 2 on 7-degree curves. This distribution suggests that fatigue- and inattention-related lane-departure crashes may be independent of alignment. Four of the 18 crashes were related to fatigue, 6 were related to inattention, and 5 were related to drinking; 3 were reported as unknown.

During the after period, 3 of the 7 serious injury and fatal head-on and opposite direction sideswipe crashes occurred on tangent sections, 1 on a 1-degree curve, 2 on 2-degree curves, and 1 on a 7-degree curve. Four of the 7 crashes were related to drinking; 3 were reported as unknown.

To account for differences in test site lengths and traffic volumes, the ADOT researchers calculated the crash rates using the following equation: Crashes per million vehicle miles traveled (MVMT) = (number of crashes x 1,000,000) / (average annual daily traffic x 365 x segment length).

"Overall, we have had very few complaints, and the centerline rumble strips are well received as a positive safety improvement," says Harper.

Lessons Learned

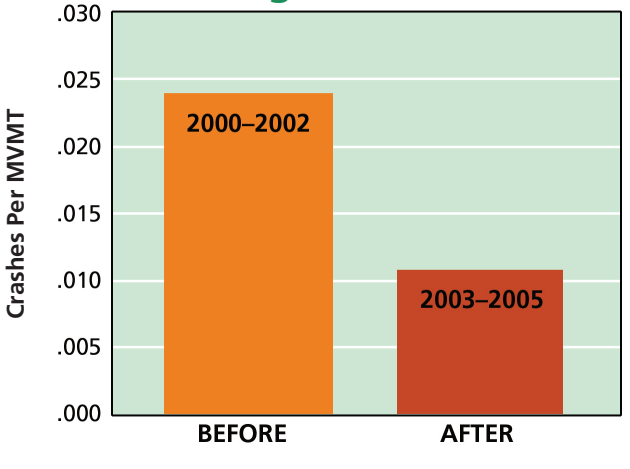
Crash mitigation. The ADOT study found that serious injury and fatal centerline crossover crashes involving fatigued, inattentive, and impaired drivers may be independent of roadway alignment (tangent versus curve). CLRSs have the potential to reduce these crashes. The crash frequency reduction was comparable to reductions found in studies in other States.

Pavement life. ADOT found no degradation of pavement that could be attributable to the milled CLRSs. Studies in other States support this finding.

Winter maintenance. ADOT found no negative impact of CLRSs on snow and ice removal. Other studies support this finding. Based on observations of CLRSs that have been in place for a number of years, no apparent damage or wear from snowplows is evident. Damage to milled rumble strips would most likely be a function of the plow equipment (design of the plow shoes, cutting edge type) and might be of interest to snowbelt States.

Noise. ADOT's pattern for milled rumble strips generates about 70 decibels of sound at 152 meters

Average Crash Rate



The average rate for fatal and serious injury centerline crossover crashes decreased by 50 percent after installation of CLRSs. *Source: ADOT.*

(500 feet). This sound level is used to limit rumble strip installations near roadside residences. Normal conversation is 60 to 70 decibels.

Constructability. ADOT found that the CLRS milling process requires dust control, using water to prevent particulates from becoming airborne. Work crews must collect millings for disposal. Crews must apply a fog coat (a light application of an emulsion to seal the exposed aggregate) to the milled area and reapply centerline pavement markings. Also, installation is most efficient when crews coordinate it with other construction and maintenance activities.

Work zone traffic control. ADOT found that during CLRS construction uniformed officers with marked police vehicles command more respect than flaggers. Lane closure by mobile operation traffic control depends on location.

Public reaction. ADOT observed a generally positive public response to CLRSs, except for a few negative comments from bicyclists. The bicyclists contend that motorists may position themselves more to the right in the lane to avoid driving on the CLRSs and thereby crowd bicyclists riding on the roadway. Generally limiting CLRSs to roadways with minimum 1.2-meter (4-foot) paved shoulders will address this concern, because the bicyclists will have a paved shoulder on which to ride. "Over time, we have modified the width and depth of the rumble strip based on motorist feedback," notes Harper.

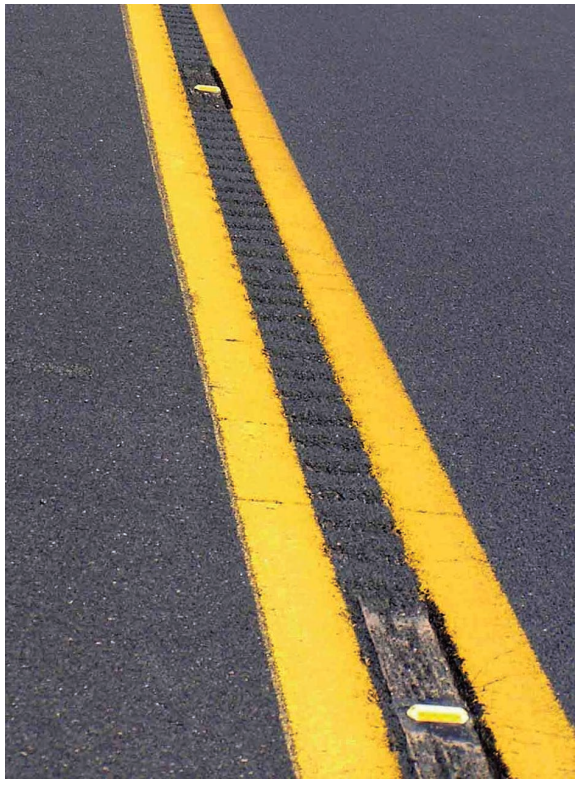
Other Studies

ADOT's findings mostly parallel those of other studies. National Cooperative Highway Research Program (NCHRP) Synthesis 339 reported on CLRS practices in the United States and Canada, finding that CLRSs have a greater potential for crash reduction on tangents than on curves due to the departure angle. CLRSs had no adverse effects on pavement life, drainage, or snow and ice removal. Also, the visibility of reapplied pavement markings was not affected.

As noted earlier, a September 2003 study by IIHS found CLRSs reduced all injury crashes by 15 percent and opposite direction injury crashes by 25 percent, based on installations at 98 sites on 338 kilometers (210 miles) in California, Colorado, Delaware, Maryland, Minnesota, Oregon, and Washington. Most sites in the study were limited to no-passing zones. There was no significant difference in crash occurrence between day and night.

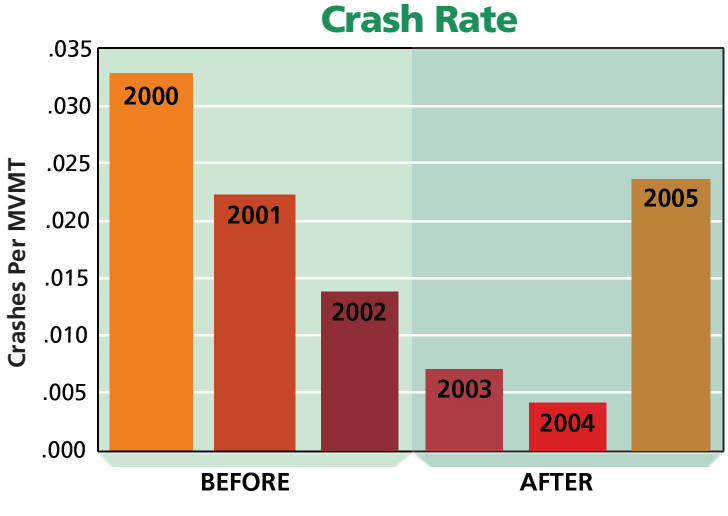
A Georgia Institute of Technology study in a driving simulator found that drivers react faster to shoulder rumble strips than to CLRSs, and 27 percent of them made initial leftward (*toward* the opposite lane) corrections upon contacting CLRSs. This might have been due to simulator conditions, however.

Pennsylvania State University field research found that CLRSs had a statistically significant effect on lateral vehicle placement away from the centerline, and decreased the variance of lateral placement. The researchers found no effect on speed.



ADOT

ADOT was concerned that CLRS constructability could be affected by retroreflective pavement markers but found that it could install the milled strips and recessed markers without conflict.



The crash rates also have decreased (comparing 3 years before with 3 years after CLRS installation). Although the number of crashes in 2005 was half the number of crashes in 2002, the 2002 crashes occurred on higher volume roads—sites 4 and 9. The higher volume roads experienced a greater change in crash rate than the lower volume roads: 88 percent reduction for the higher volume roads compared to 40 percent for the lower volume roads. *Source: ADOT.*

Recommendations

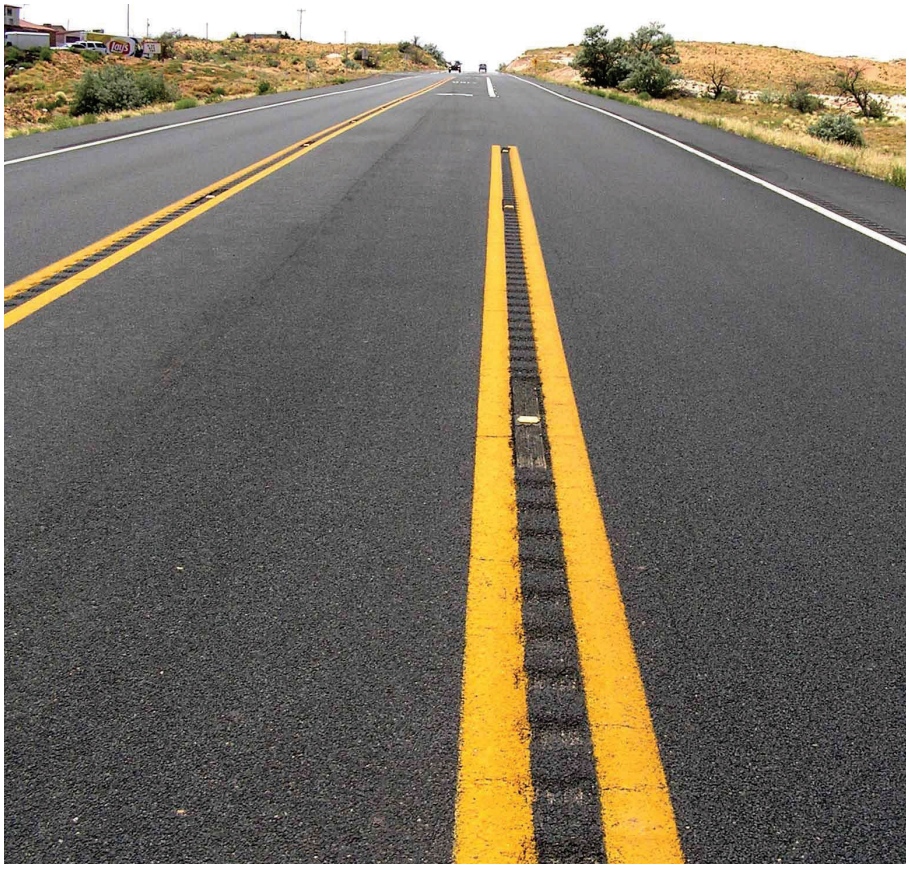
Many States have installed and evaluated CLRSs, and most evaluations have found statistically significant positive benefits. ADOT's Flagstaff District has documented no adverse effects related to installation of CLRSs.

ADOT

Shown here are milled CLRSs installed in a two-way passing zone on an Arizona roadway.

Based on their own findings and those of other States and studies, the ADOT researchers believe that milled CLRSs have the potential to prevent and reduce opposite direction crashes on undivided highways. The researchers recommend prioritizing installations on high-volume, high-speed rural roads, and coordinating placement with scheduled highway projects.

The researchers recommend a standard CLRS width of 30.5-centimeters (12 inches). Further, a distinct spacing pattern should be used for centerlines to help drivers distinguish them from shoulder rumble strips. The researchers further recommend using a pattern similar to that used by Michigan and Missouri, which consists of a pair of grooves at 30.5-centimeter (12-inch) spacing separated by a 61-centimeter (24-inch) gap. This pattern has a frequency and amplitude that generates effective tactile and audible stimuli, according to research by NCHRP, the University of Massachusetts, the Kansas DOT, and the Transportation Research Board.



ADOT

ADOT installed milled CLRSs at this left-turn pocket.

Because CLRSs cause high-decibel sound, DOTs should avoid using them in residential areas. The researchers recommend that DOTs install CLRSs on continuous lengths of highway, avoiding placement in intersections or adjacent to left-turn lanes to eliminate noise produced by the turning traffic.

Finally, guidelines for appropriate use of CLRSs should be based on a logical, written policy to ensure effective and consistent use.

Future Installations

This study found that CLRSs effectively reduce crossover crashes involving fatigued and inattentive drivers. Based on the results of this study, ADOT currently is finalizing a CLRS policy, developing installation guidelines, creating CLRS groove pattern standard details, and defining the elements of an implementation program.

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The authors gratefully acknowledge the cooperation of ADOT's Flagstaff District in supporting installation of CLRSs for this evaluation.

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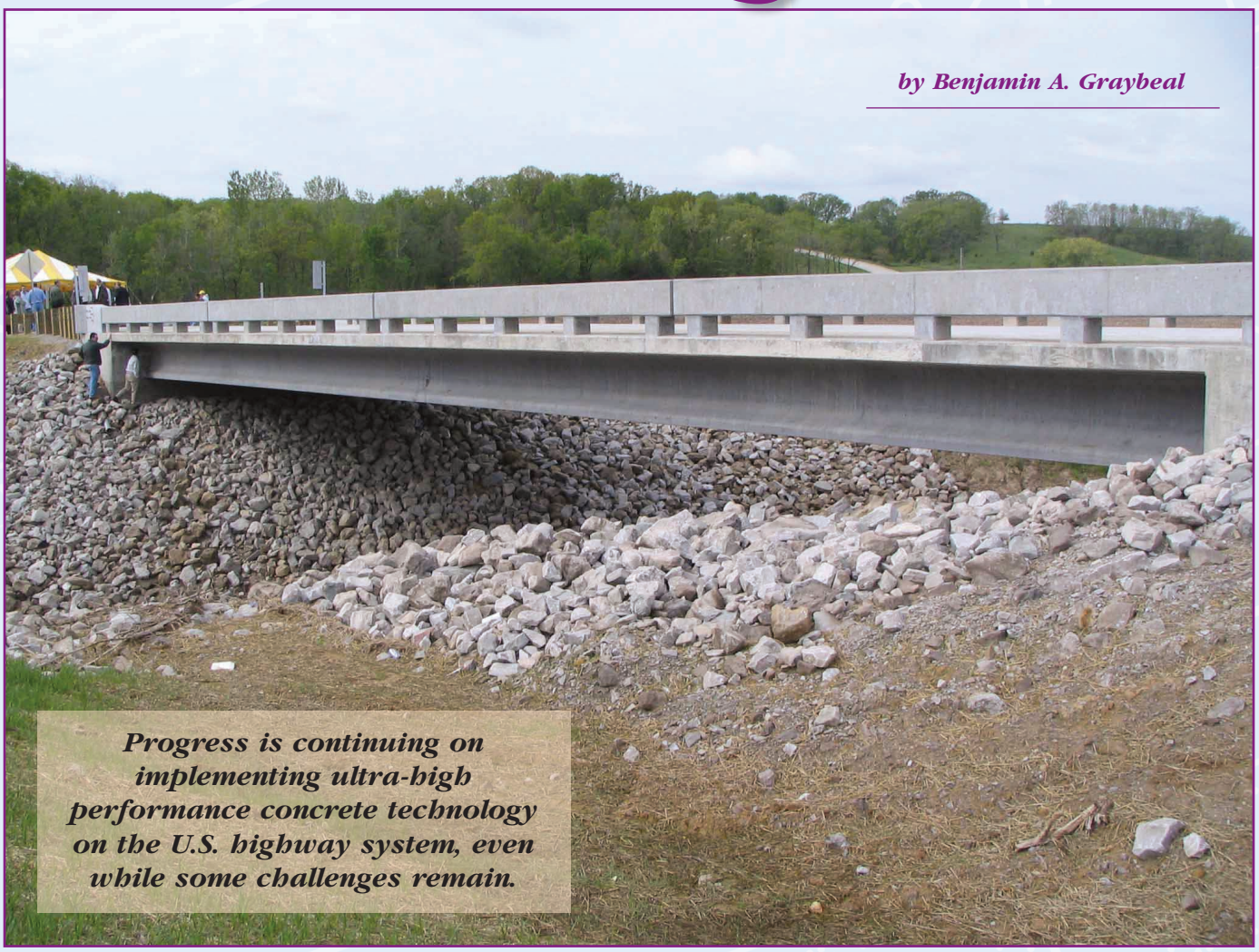
UHPC Making Strides

by Benjamin A. Graybeal



Progress is continuing on implementing ultra-high performance concrete technology on the U.S. highway system, even while some challenges remain.

As in most of the developed world, the highway infrastructure in the United States is greatly dependent on concrete and steel. Following the infrastructure construction that occurred in this country in the mid-20th century, decades of wear and tear have focused attention on the need for durable, long-lasting structures.

Innovative materials with enhanced mechanical and durability properties make it possible to construct new infrastructure and rebuild aging highways and bridges with structures that last longer. Over the past two decades, significant advances in research on cementitious materials have led to development of a new class of market-ready materials with many times the strength and durability of conventional concretes.

These new concretes tend to contain high percentages of cement and silica fume, have low water/cement ratios, and include steel fiber reinforcement, all of which contribute to the advanced material behaviors. For instance, compressive strength in these new concretes is more than seven times that of conventional concrete, while tensile cracking strength is three times greater. This emerging technology, known as ultra-high performance concrete (UHPC), has the potential to affect the U.S. highway system significantly.

Challenges remain, however, limiting widespread implementation of projects using this new technology. Among them are the lack of design code provisions, inadequate industry familiarity with the product, and high initial costs. Addressing these issues will require significant knowledge transfer, industry support and buy-in, and greater reliance on life cycle costing.

The Federal Highway Administration (FHWA) initiated UHPC research in 2001 and since then has made major strides in introducing the concrete and transportation industries to this next generation of concrete technology. The first UHPC I-girder bridge opened to traffic in 2006 (Mars Hill Bridge in Wapello County, IA), a second UHPC superstructure

(Above) Shown here is the Nation's first completed UHPC I-girder bridge, the Mars Hill Bridge, located in Iowa's Wapello County.

bridge opened to traffic in October 2008 (Cat Point Creek Bridge in Richmond County, VA), and a UHPC decked girder bridge opened to traffic in November 2008 (Jakman Park Bridge in Buchanan County, IA).

"There is a strong push by bridge owners and bridge industry officials to develop and deploy innovative, higher performance materials that have the potential for making significant positive impacts on bridge performance while resulting in lower life cycle costs," says Ian M. Friedland, FHWA's technical director for bridge and structures research. "UHPC is one of these new, innovative materials with such a potential."

The Challenges to Widespread Deployment

As is frequently the case with established industries serving the public works sector, implementation of innovations occurs rather methodically. FHWA has identified five specific reasons for the slow pace of UHPC deployment.

First, unless industry sees a clear financial benefit, manufacturers are unlikely to invest in innovative technologies. Manufacturers who see a risk in using a new material are hesitant to modify current operations so that they can produce the innovative product efficiently. As would be expected, the costs of fabricating UHPC components thus are significantly higher than the costs of manufacturing conventional concrete components.

Second, owners (in this case government agencies) traditionally are justifiably risk-averse and tend to take measured responses when presented with innovative solutions to existing problems. Limited budgets and concern that a new approach will be less successful than a conventional one can reduce the desire to try creative solutions.

Third, the lack of design code provisions relevant to the advanced properties of these innovations is a clear hinderance. This gap effectively requires that all structural designs proceed along one of two paths. The designer can choose to make limited use of UHPC, in effect using the advanced properties of UHPC simply as an added safety factor. Alternatively, the designer can rely on research results, effectively requiring some level of demonstration testing prior to implementation.

Fourth, the limited number of applications of UHPC to date necessarily means that limited experience is available with regard to inspection, maintenance, and repair of UHPC structures. Although FHWA researchers and others expect these structures to perform well once deployed into the highway system, UHPC is not immune to damage from overheight or wayward vehicles, or unanticipated structural loadings. Methods for inspecting UHPC for damage and for repairing UHPC components will need to be developed prior to widespread acceptance of this material by the highway industry.

Finally, the higher cost of the constituent materials in UHPC necessarily mean that it will have a higher per-unit volume cost than conventional and high-performance concretes. This increase is unlikely to be offset entirely through the use of more efficient structural designs. To compensate for the greater cost, designers need to use a life cycle costing approach that takes into account the enhanced durability of UHPC.

UHPC Research Studies

Research related to the development, properties, and application of UHPC is progressing despite these hurdles. Many university researchers have secured industry and government funding for UHPC-related studies. In particular, the most recent Federal transportation legislation—the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—contained funding designated specifically for UHPC research. Compared to funding in Europe and East Asia, however, UHPC research in the United States remains more constrained.

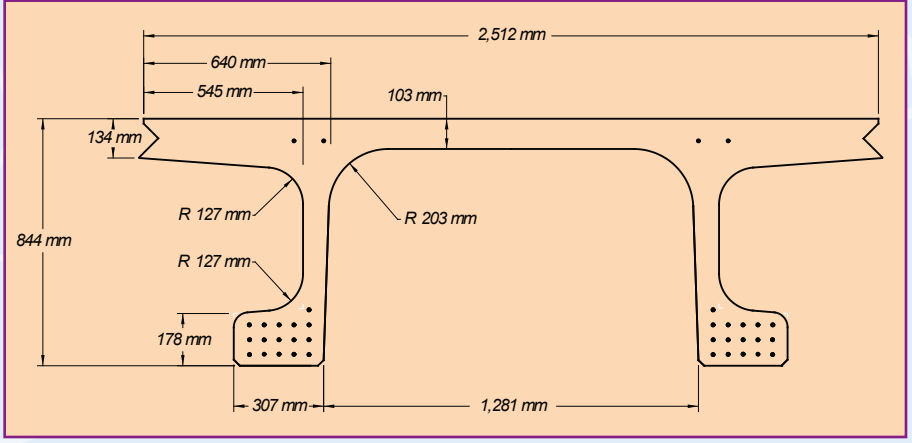
The intent of FHWA's UHPC research is to (1) determine the properties of UHPC that would be demonstrated when used in the highway system, (2) explore the best applications for UHPC in the highway system, and (3) aid in the initial deployment of UHPC in transportation structures. The early phases of this research, now complete, focused on determining the basic mechanical and durability behaviors of UHPC and establishing how this material would behave when used in common prestressed concrete superstructure elements.

Modular UHPC Superstructure and Deck

Four FHWA research studies on UHPC are underway. The first is a project to develop a modular precast, prestressed concrete decked girder system applicable to typical highway bridges around the United States. The intent is to combine the increased strength and enhanced durability of UHPC into a packaged bridge with components fabricated offsite at a precast/prestressed plant and then quickly and efficiently transported and assembled onsite.

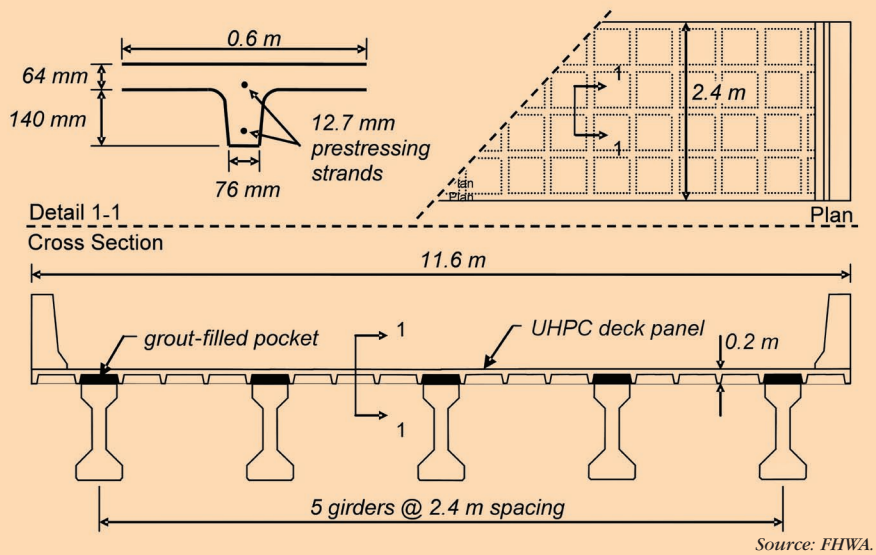
Many bridges in the U.S. highway system span 20 to 35 meters (65

Cross-Section of a UHPC Decked Girder (π-Girder)



This diagram shows the proposed second-generation component designed to span up to 30 meters (98 feet) while allowing for overnight bridge construction or reconstruction. *Source: FHWA.*

Proposed UHPC Two-Way Ribbed Precast Bridge Deck



Source: FHWA.

to 115 feet) and are composed of superstructures and decks that are nearing the ends of their design lives. Reconstruction to replace these bridges likely will exacerbate traffic congestion because of lane closures. Development of modular components that allow for overnight replacement of superstructures and decks will be a major leap forward.

Between 2004 and 2006, FHWA led the effort to design, construct, and test a first-generation UHPC superstructure and deck modular component. In conjunction with FHWA, researchers from the Massachusetts Institute of Technology designed the first-generation component to be fully structurally optimized, with global flexure and shear being the driving factors. Given the lack of experience with components of this type, less emphasis was placed on fabrication considerations and localized structural behaviors in this first-generation component than on structural optimization.

FHWA designed a second-generation UHPC decked girder module to address the shortcomings of the first-generation component, namely difficult fabrication and insufficient local flexural strength. The first-generation module's test program demonstrated that the component expressed acceptable global structural behaviors, but that larger cross-sectional dimensions were necessary to alleviate local stresses and to allow for effective fabrication. The second-generation module has rounded fillets, thicker webs and deck, and no overhang blockouts.

Deteriorated Bridge Decks

The second FHWA research project focuses on developing an alternative to replacing deteriorated bridge decks when their superstructures remain viable. "Deterioration of bridge decks is among the most significant maintenance and bridge rehabilitation issues for the U.S. highway system," says FHWA's Friedland.

In recent years, U.S. researchers have pushed to develop modular deck components that can be assembled onsite during brief whole or partial bridge closures. The advanced properties of UHPC open the possibility of designing a deck component that is as strong and robust as existing cast-in-place concrete decks while also having significantly greater durability. The first phase of this effort is complete. The component that FHWA developed is a two-way ribbed precast deck element.

FHWA's study focused on analytically determining the viability of this solution in terms of structural behavior. The study demonstrated that a UHPC bridge deck panel can exhibit capacities equivalent to conventional concrete decks while being 30 percent lighter. The enhanced mechanical and chemical bond of UHPC to discrete reinforcement also allows for reduced connection sizes, thus potentially simplifying installation of precast deck elements.

Quantification of UHPC Properties

The third FHWA research effort focuses on quantifying the advanced structural and durability properties of UHPC. The existing body of knowledge on the tensile fatigue behavior of UHPC is limited. For U.S. design codes to allow general

FHWA constructed this UHPC π-girder bridge as a demonstration and test bed at the agency's Turner-Fairbank Highway Research Center in McLean, VA.

When the Cat Point Creek Bridge (shown here) opened to traffic in Virginia in October 2008, it was the second UHPC bridge in the United States.

use of UHPC in transportation structures, researchers need to demonstrate that the material's advanced tensile mechanical properties are applicable over a wide range of environmental and mechanical stressors.

One phase of this research involves investigating the postcracking tensile fatigue of UHPC subjected to various stress and strain ranges. Another phase will investigate the influence of chloride-laden water on steel-fiber reinforcement of cyclically stressed cracks. Within this overall research, another part of the project will investigate the durability and structural response of a full-scale UHPC modular deck component stressed both environmentally and structurally, and then will compare those results to a similarly stressed conventional concrete component.

Industry Issues

The fourth FHWA research project focuses on addressing issues of immediate importance to the industry tasked with fabricating UHPC components. One topic under investigation is the use of concrete cubes instead of cylinders when determining compressive strength. Compressive strength is a commonly captured structural concrete property, but obtaining this property for very high strength concretes is problematic due to the high testing machine forces necessary and the lack of an inexpensive means to ensure parallelism of the cyclinder ends.

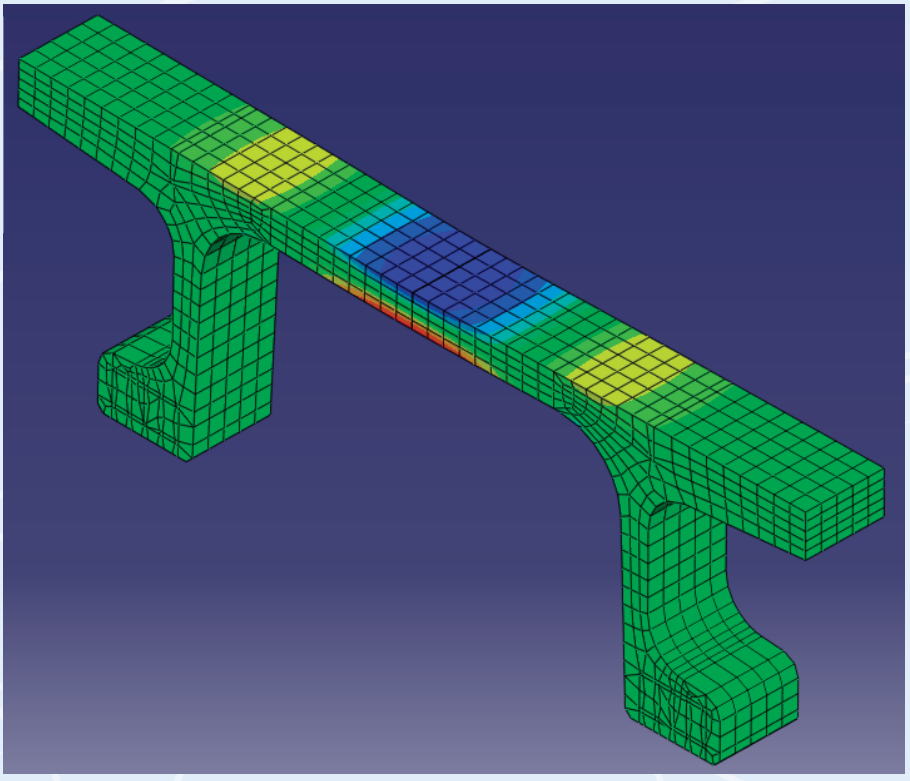
Testing cubes to determine compressive strength is rare in the United States, probably because cylinder molds are cheaper and easier to use than cube molds. But using cubes can relieve the need to prepare the ends of a cylinder for testing through a time-consuming and expensive grinding process. Cubes are fabricated with parallel ends that thus can be tested with minimal preparation.

Another topic is the potential use of ultrasonic inspection techniques to determine the setting state of UHPC within a closed, restraint-inducing formwork. This research is ongoing but so far has demonstrated that properties of ultrasonic waves can be monitored as a surrogate for UHPC strength and shrinkage.

First Deployment: Iowa

The Mars Hill Bridge in Wapello County, IA, is the first UHPC bridge on a public road in the United States. This three-girder bridge spans 33 meters (108 feet) and has 1.07-meter (3.5-foot)-deep prestressed girders. The designer modified the girders from the standard Iowa bulb-tee design (a prestressed I-girder designed to span longer distances than conventional prestressed I-girders) by using thinner flanges (the shallower tops and bottoms) and a narrower web (the thin part of the beam connecting the flanges). The designer also eliminated the normal steel shear reinforcing bars because testing demonstrated that the UHPC, with its steel-fiber reinforcement, was sufficient to carry the design loads.

"Two of the biggest challenges with the Wapello County bridge were the lack of a U.S. design specification and limited experience working with UHPC," says Norm McDonald, director of the Iowa Department of Transportation (Iowa DOT) Office of Bridges and Structures. "The design capacities of the bridge beams were determined using design guidelines developed in France and verified by testing a 22-meter [71-foot]-long full-scale beam. Although two local precast plants were certified to produce the beams, their bids were higher than expected



This computer-generated cross-section shows the second-generation π-girder that FHWA and the Iowa DOT are deploying in a bridge in Iowa's Buchanan County. *Source: Sunwoo Park, PSI, and FHWA.*

due to production concerns, and a nonlocal precast company was selected to produce the beams. The project provided an excellent opportunity for the Iowa DOT and our project partners to gain valuable experience in design, testing, and fabrication methods involving UHPC."

The bridge opened to traffic in early 2006. "Our project was a great success as we were able to collaborate with industry, academia, and State transportation officials to advance the use of UHPC and demonstrate the great potential of UHPC in rebuilding the infrastructure of this country," says Brian P. Moore, P.E., Wapello County engineer and zoning administrator.

Second UHPC Structure: Virginia

In Richmond County, VA, the Cat Point Creek Bridge opened to traffic in October 2008 as the second UHPC bridge in the United States. This 10-span bridge contains one UHPC span of 24.8 meters (81.4 feet) with five 1.1-meter (3.7-foot)-deep girders. The prestressed girders included a one-for-one replacement of conventional concrete with UHPC. The tensile properties of UHPC allowed for the elimination of the traditional mild steel shear reinforcement that is normally cast into concrete girders. A local precast plant in southeastern Virginia fabricated the girders.

Third Deployment: Iowa

FHWA and Iowa DOT have designed a third bridge, which uses the second-generation UHPC modular decked girder component mentioned earlier. FHWA was responsible for the conceptual design of the UHPC component, while the Iowa DOT designed the remainder of the bridge. Buchanan County, in conjunction with Iowa DOT, constructed this bridge, which opened to traffic in November 2008. As opposed to the first two deployments, this bridge is the first one to make significant use of the advanced behaviors of UHPC through structural optimization of the bridge components.

Future Deployments

The use of UHPC in the highway industry is progressing in the United States just as it is around the world. Other State departments of transportation (DOTs), such as Florida, Georgia, and New York, are investigating the use of UHPC on their highways. Superstructures with both longer and lighter prestressed girders are a possibility. Georgia, Iowa, and New York are contemplating using UHPC for precast modular deck components and as a cast-in-place cementitious material in joints. Some DOTs, such as Iowa's, also are considering using UHPC in specific areas where high durability is required, such as approach slabs between pavement and bridge decks.

Advanced cementitious materials exhibiting greater strength and durability clearly have a role to play in the construction and reconstruction of bridges and other critical highway structures. Research to date has demonstrated that the properties of UHPC will open many new avenues for engineers and bridge architects. However, certain challenges will continue to hinder the deployment of UHPC into the civil infrastructure. Most significantly, the high per unit volume cost of UHPC and the lack of codified design provisions are hurdles to be addressed. That is not to say, however, that UHPC doesn't have a clear role to play in addressing the challenges faced by the Nation's highway infrastructure.

"The needs and opportunities for UHPC certainly exist," says FHWA's Friedland. "We just need to address these technical and administrative impediments in a rational and systematic way."

Benjamin A. Graybeal, Ph.D., P.E., is the structural concrete research program manager at FHWA's Turner-Fairbank Highway Research Center in McLean,VA. His duties include managing programs focused on high-performance concrete and UHPC. He holds bachelor's and master's degrees in civil engineering from Lehigh University and a Ph.D. in structural engineering from the University of Maryland.

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Bringing Innovations to Market

by Julie Zirlin

FHWA's Technology Partnerships Program smoothes deployment in the transportation industry.

Transportation-related technologies can hit any number of roadblocks on their way from the drawing board to the vehicle or roadway. Innovations might be developed into late-stage prototypes with well-established proofs of concept, for instance, but still be kept from commercialization because of a lack of funding for final development and evaluation in a real-world setting.

By offering a technology transfer funding boost, a Federal Highway Administration (FHWA) program is helping highway industry innovations make the leap from promising prototypes to market-ready products. The Technology Partnerships Program provides grants to fund the critical final steps in developing technologies with potential to improve highway quality and safety or reduce construction-related congestion. The program, established in 2007, also promotes partnerships to test and demonstrate those technologies in real-world settings.

"One of our agency priorities is to advance deployment of innovations that address the challenges facing our Nation's transportation system," says FHWA Executive Director Jeffrey F. Paniati. "Private industry is an essential partner in developing solutions to these challenges. The Technology Partnerships Program is a way to get new technologies to the marketplace faster so they can be put to use."

Although FHWA has long supported technology research and development, this is the first time the agency has provided grants to general industry (under a broad solicitation, unlike the Small Business Innovation Research program, which is very targeted to specific technologies) for late-phase technology development. The grants enable companies to adapt nonhighway-related innovations to highway use or refine existing equipment, materials, or processes that are not common practice in the transportation industry.

"The Technology Partnerships Program is very important to the highway industry because if we can

(Above) Researchers are validating the intelligent asphalt compaction analyzer, an innovative technology, during construction of a full-depth asphalt pavement at Tecumseh Road in Norman, OK. *Photo: Oklahoma University.*

3M

An FHWA Technology Partnerships grant is helping improve the retroreflectivity of all-weather pavement markings, such as these, under wet, nighttime conditions, ultimately enhancing safety in highway work zones.

put any of these emerging technologies into mainstream usage by stakeholders, we may have an opportunity to reduce the escalating costs of maintaining our surface infrastructure," says David McKee, director of membership and technical assistance for the American Traffic Safety Services Association.

He adds that advancing technology is particularly important to the private sector because "we are competing with the emerging roadway markets in China, Brazil, and India," where expanding economies and skyrocketing numbers of construction projects are driving up the prices of materials worldwide. "We need new technologies, backed by Federal support, to provide a safer, cleaner, and more efficient system," McKee says.

Accelerating Innovation Deployment

The Technology Partnerships Program is part of Highways for LIFE (HfL), an FHWA initiative to accelerate innovation in the highway industry. HfL's focus is improving safety and quality while reducing construction-related congestion. In addition to Technology Partnerships grants, the HfL initiative features demonstration construction projects, technology transfer efforts, technical assistance, stakeholder involvement, and information dissemination.

So far, FHWA has awarded Technology Partnerships grants of $200,000 to $500,000 to five companies to refine and evaluate prototype technologies. The projects include an all-weather pavement marking system for work zones, an intelligent asphalt compaction analyzer, an aggregate imaging system, an automated pavement marker placement system, and an asphalt binder cracking device.

"This program accelerates the process of getting technology research from just an idea to where it can be a beneficial tool for the whole industry," says Jay Lemon, president of Haskell Lemon Construction Co., which received a grant to develop the compaction analyzer.

One benefit of the program, he says, is that it provides researchers extensive opportunities to test prototypes on actual jobs, enabling potential users to thoroughly evaluate the effectiveness of the innovations and offer feedback.

"We're out paving every day, so when researchers have a new version of a prototype, they can try it on our equipment and interview the crew members using it," says Lemon. "In the past, researchers might get the opportunity 3 or 4 days a year to put their ideas to work in real paving situations."

Another benefit is that the program makes it possible for highway agencies to try innovations at minimal cost, says State Materials Engineer Thomas Baker of the Washington State Department of Transportation (WSDOT).

"A lot of times, State highway agencies don't have the money to take a risk on these new technologies. This program really helps reduce that risk," Baker says. "Agencies can try technologies at a modest investment, mainly just the time to do the evaluation. Meanwhile, we provide a useful evaluation for the manufacturer."

Although some prototypes might become commercially viable without

About the Grant Program

The purpose of the Technology Partnerships Program is to partner organizations and companies with the highway construction industry to accelerate adoption of promising innovations that reduce congestion from construction and improve safety and quality.

The program is intended to fund proven innovations that have been developed to late-stage prototypes, with their proofs of concept well established, and that require further development, testing, and evaluation in a real-world setting before they would be ready for commercialization. The innovation must make a significant contribution to achieving at least one of the following HfL goals: improving project and/or work zone safety (including worker or user safety), reducing construction congestion, accelerating construction, or improving quality. Applicable innovation areas include technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, or practices used in the financing, design, or construction of highways or bridges.

Competition is open to all nonprofit and for-profit organizations except State and local governments and institutions of higher education. State and local agencies, local municipalities, and academic institutions are excluded from competition as prime awardees but are encouraged to participate as partners at the sublevel.

In 2007, FHWA received 55 applications and made 5 awards. The number of applications received in 2008 will be made public when the awards are announced.

For more information on the grant program, visit www.fhwa.dot.gov/hfl/tech.cfm.

3M

During testing of all-weather pavement markings for work zones, workers used a hand cart to apply paint samples with varying thickness, bead mixture, and other variables to a New Orleans, LA, roadway.

funding from programs such as Technology Partnerships, "others might take 5 to 10 years or longer to make it to the market," Baker says.

Enhancing Work Zone Safety

Navigating a work zone's unfamiliar traffic pattern can be a challenge for drivers, especially when dark, rainy conditions obscure lane markings. Water reduces the retroreflectivity, or ability to reflect light back toward its source, of conventional pavement markings, which consist of glass beads dropped into paint.

The 3M company developed an all-weather paint system that is highly reflective in both dry and rainy conditions, making it easier for drivers to see in any weather. The system consists of high-build waterborne paint and glass beads, which provide good visibility in dry conditions. The system also includes optical elements made of a ceramic core surrounded by tiny, high-refractive-index beads. The second set of beads provides retroreflectivity in wet conditions, particularly rain.

A Technology Partnerships grant is helping 3M customize the pavement marking system for use in work zones, according to Fuat Aktan of the company's Traffic Safety Systems Division. The firm developed more than 20 samples by changing variables such as bead mixture, drop rate, paint type, and paint thickness. The research team applied the samples to a New Orleans, LA, roadway and evaluated them under normal traffic in dry, wet, and simulated rain conditions. The researchers measured the retroreflectivity of the samples at the beginning of the test and after they were exposed to wear. From this study, the company determined the three samples that retained the most retroreflectivity.

The researchers then used those three successful samples in human factors experiments at the Texas Transportation Institute's rain range (a testing facility that simulates rain) in College Station, TX. The samples, along with two commercially available marking systems, were applied to a test track, where test participants evaluated them for visibility under dry, wet, and rainy nighttime conditions. The three samples performed equally well under all conditions and significantly outperformed the conventional markings under wet (just after rain) and ongoing rain conditions.

In the next phase of the project, 3M researchers will work with several State highway agencies to test the pavement marking system in work zones, monitoring driver behavior at various times of the day and night in dry and wet conditions.

The goal is a pavement marking system that maintains optimal visibility and enhances driver safety, but also meets work zone requirements such as faster application and drying times. The product also needs to be flexible enough to meet varying durability requirements for different types of work zones.

Assuring Good Asphalt Compaction

Proper compaction of newly applied asphalt helps assure a crack-free paved surface and longer lasting roadway. But if compaction occurs incorrectly, it can result in early degradation of the pavement. In the past, researchers verified compaction quality by testing core samples extracted from the hardened asphalt. If tests showed compaction was inadequate, workers had to repave that section.

The Haskell Lemon company is using its FHWA grant to refine and test a prototype intelligent asphalt compaction analyzer. The system, when installed on a vibratory compactor, measures the density of asphalt pavement in real time, so workers can fix compaction problems while the asphalt is still pliable. The company expects the system to result in better quality pavements, shorter construction times, and lower costs.

The analyzer consists of sensors and computational devices that continuously measure the density of asphalt pavement, says Sesh Commuri, associate professor of engineering at The University of Oklahoma, who developed the concept. The system takes into account process parameters such as mix type, lift thickness (the thickness of the layer of pavement placed by the asphalt paver), and mix temperature.

Using neural network technology, a sophisticated data modeling approach that mimics biological nervous systems, the tool analyzes patterns in the vibration of the rollers on the compaction equipment to determine the compaction level being achieved. By viewing information displayed on a monitor, the equipment operator can make needed adjustments to the compaction level before the road is completed.

Haskell Lemon Construction Co.

The intelligent asphalt compaction analyzer components (inset) consist of a GPS receiver (not shown, but mounted on roof of compactor, right) and an embedded computer (circled, right), which mount on a vibratory compactor. The device measures the density of asphalt pavement in real time so workers can detect and fix compaction problems during the paving process, saving time and money.

Commuri developed a prototype of the compaction analyzer working with Haskell Lemon and Volvo Construction Equipment. Initial test results showed that the asphalt density estimated by the system compares well with density measured in roadway cores.

The next step involves developing a commercial prototype and validating its effectiveness. Haskell Lemon crews will install five units on vibratory compactors and test them on construction projects for the Oklahoma Department of Transportation. The goal is an easy-to-use commercial product that will help produce higher quality asphalt pavements, Commuri says.

Automating Aggregate Analysis

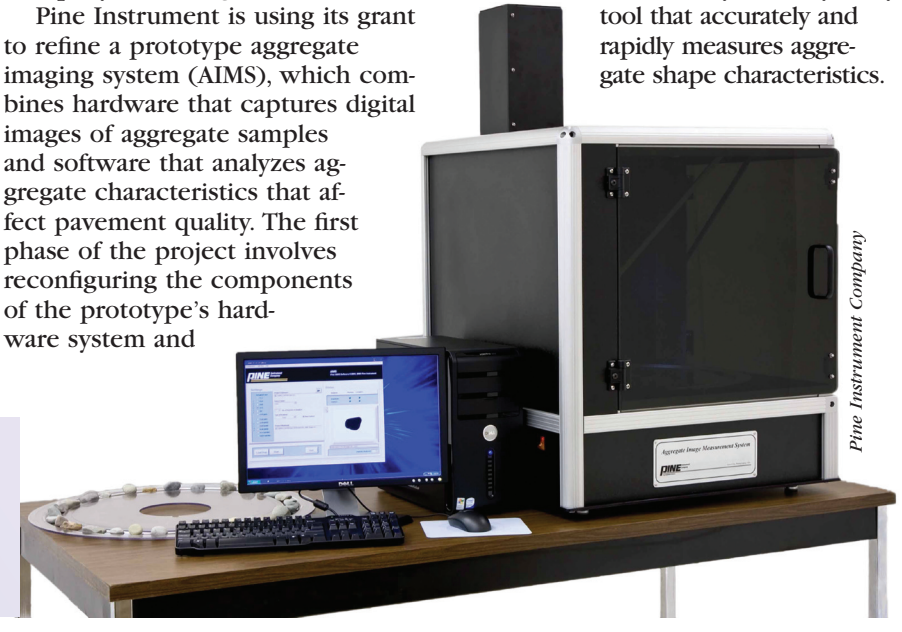
Highway industry research shows that the characteristics of aggregates used in hot-mix asphalt, hydraulic cement concrete, and aggregate pavement layers affect the structural integrity and durability of pavement systems and the skid resistance of pavement surfaces. Those characteristics include shape, such as round or flat; angularity, the sharpness of the corners of the aggregate particles; and texture, the smoothness or roughness of the particle surface.

Manual methods now used to measure aggregate characteristics can produce inconsistencies in measurement, quality assurance, and mix design, says David A. Savage, marketing manager for the Pine Instrument Company, another grant winner.

Pine Instrument is using its grant to refine a prototype aggregate imaging system (AIMS), which combines hardware that captures digital images of aggregate samples and software that analyzes aggregate characteristics that affect pavement quality. The first phase of the project involves reconfiguring the components of the prototype's hardware system and enhancing the analysis software to make results easier to interpret.

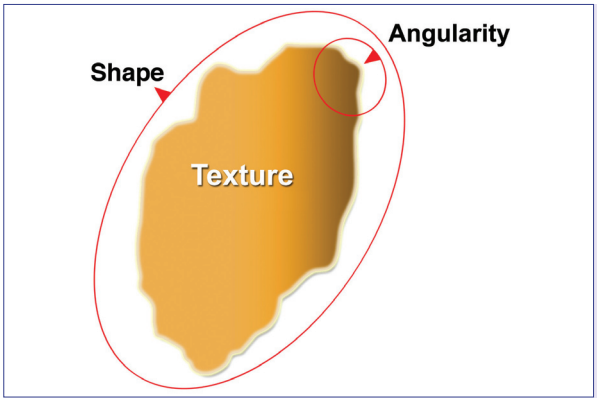
In the project's interlaboratory study, 28 university, commercial, and highway agency laboratories will evaluate the reproducibility of the refined AIMS equipment and procedures. The company will provide participating laboratories with the equipment and materials needed, and Texas A&M University, a project partner, will analyze the data from those tests.

The goal is to develop a user-friendly, industry-ready tool that accurately and rapidly measures aggregate shape characteristics.



Pine Instrument Company

AIMS, shown here, is an integrated hardware/software system that automates the process of measuring the characteristics of pavement aggregates.



Pine Instrument Company

AIMS characterizes aggregate properties such as shape and angularity that influence pavement performance. The figure shows a closeup illustration of a rough-edged aggregate particle.

Such a tool, according to Savage, would offer an automated method of qualifying aggregate shape properties and surface texture to meet construction specifications, ensure good pavement performance, and ultimately enhance roadway safety.

Reducing Worker Risk

Few highway workers look forward to this job: riding on a seat attached to the underside of a truck, inches from traffic, installing reflective pavement markers by hand. Although the markers enhance roadway safety by helping drivers see lanes at night, the process of installing them manually puts workers at risk.

With the help of a Technology Partnerships grant, Stay Alert Safety Services is working with the Illinois Institute of Technology and Detail Technologies, Inc., to develop an automated system for safer installation of pavement markers.

The prototype system, which fits on the back of a flatbed truck, applies adhesive and drops markers into place with a robotic arm. A computer in the truck cab operates the system, effectively removing workers from direct exposure to traffic, says Tony Collins, Stay Alert's project manager.

Turning the prototype into a market-ready product involves redesigning, refining, and testing the system. Refinements aim to improve the efficiency and reliability of the system components that hold and dispense the markers, apply the adhesive, mount the hardware components on the truck, and operate the system from the truck cab.

Stay Alert and independent observers conducted tests on Highway 158 in North Carolina, a two-lane, two-way road with variable elevations, and they reported very favorable results. Additional refinements will be made related to the applicator's speed and efficiency before using the equipment on pavement marker installation projects in the spring of 2009.

State highway agencies and other companies that install pavement markers have expressed interest in the technology because of its potential to improve work zone safety, says Collins. "They recognize that manual installation of pavement markers is a serious safety risk to workers," he says. "Not many people want to get under that truck."

Prolonging Pavement Life

Cold climates can cause asphalt pavements to contract and crack if the right type of asphalt binder is not matched to the local climate. Cracked pavements ultimately lead to premature deterioration of the roadway. The asphalt binder that bonds with aggregates to make hot-mix asphalt is the primary mechanism for providing resistance to low-temperature cracking. A reliable test to determine the susceptibility of various binders to thermal cracking could extend pavement life, reducing construction-related congestion and saving taxpayer dollars.

EZ Asphalt Technology LLC is using a Technology Partnerships grant to develop an asphalt binder cracking device (ABCD) that indicates the lowest temperature at which an asphalt binder sample will remain intact, providing a simple, accurate test for grading binders.

"[The test] will ensure that a road is built with the correct grade of asphalt for temperature conditions at the site," says Sang-Soo Kim, owner of the company and associate professor of civil engineering at Ohio University. The device is an improvement over conventional test

Stay Alert Safety Services

This automated pavement marking placement system fits on a flatbed truck and is operated from the cab, reducing safety risks for highway workers.

methods, which have been known to produce a margin of error, especially for newer types of asphalt, and also have several more procedural steps.

The ABCD creates thermal cracking conditions similar to those in the field. The unit consists of a metal ring equipped with a strain gauge and temperature sensor that fits in a silicone mold. Workers pour heated asphalt binder around the ring, and the device is cooled in an environmental chamber, which is a device that can control a variety of environmental factors, such as temperature and humidity.

As the temperature drops, the asphalt binder contracts to a greater degree than the metal restricting the binder, causing the binder to fracture. A computerized data acquisition system captures the temperature and stress level at which the fracture occurs.

Planned modifications to the ABCD prototype include redesigning the ring and mold for easy specimen preparation, testing, and cleanup. Researchers also will refine the test procedure to produce faster, more accurate results.

Thirty-two laboratories volunteered to participate in the interlaboratory study and use the ABCD to test four types of asphalt binders, with eight replications each.

The ABCD system includes a computer (left) to collect data and control the environmental chamber (right), which cools the asphalt binder samples at a controlled rate.

EZ Asphalt Technology, LLC

The evaluation will determine how consistent the test is when used by different laboratories and collect feedback on its ease of use.

Improving America's Driving Experience

FHWA's Technology Partnerships Program provides a financial incentive to companies to further develop innovations with potential to improve project or work zone safety, accelerate construction, reduce construction-related congestion, or improve quality. The idea behind the program is to help companies overcome the hurdles separating workable prototypes from market-ready technologies.

"I think this program is going to have a big impact on moving these technologies rapidly from prototype to everyday usage," says WSDOT's Baker. "It gives us the opportunity at a very reasonable investment to get the technologies out into the highway construction industry, the owner States, and the testing community so they can be tested and used."

FHWA sought applications for a second round of Technology Partnerships grants in summer 2008 and plans to announce the recipients in spring 2009. As both rounds of funded projects go through the stages of refinement, testing, and evaluation, they will travel a faster path to the marketplace, where the highway industry and, eventually, road users can reap the benefits.

"When we can harness technology to improve the quality and safety of our roadways and reduce the delays and congestion associated with building and rehabilitating highways, we can increase customer satisfaction with the highway system," says HfL Team Leader Byron Lord. "And that's our ultimate goal: improving the American driving experience."

In the ABCD testing process, asphalt binder is poured around metal rings inside silicone molds, shown here, and then cooled at a controlled rate inside the environmental chamber until the binder samples crack. The cracking temperature in the cooling unit is closely related to field pavement cracking temperature.

EZ Asphalt Technology, LLC

Julie Zirlin is the Technology Partnerships Program coordinator in FHWA's HfL office. She has held a variety of positions in the U.S. Department of Transportation since 1994.

For more information on the Technology Partnerships Program, visit www.fhwa.dot.gov/hfl/tech.cfm or contact Julie Zirlin at 202–366–9105 or julie.zirlin@dot.gov. To learn more about the HfL initiative, see www.fhwa.dot.gov/hfl.

Fostering a Culture of Ethics

Establishing and maintaining strong moral standards in the workplace are essential to building public trust and delivering the transportation program effectively.

by Jim H. Crumpacker

(Above) Shown here is the postcrash scene in the I–90 tunnel in Boston after a ceiling tile dislodged and fell onto the roadway, crushing a car and killing one of the occupants. The open area in the ceiling is the original location of the concrete panels. Investigations revealed significant failures in both construction and oversight. *Photo: USDOT.*

In a report released in January 2008, the nonprofit Ethics Resource Center (ERC) revealed that 52 percent of Federal, 57 percent of State, and 63 percent of local government respondents witnessed violations of ethical standards, policies, or laws in their workplaces. The report, *National Government Ethics Survey: An Inside View of Public Sector Ethics*, further stated that a similar trend is occurring in the private and nonprofit sectors. For government agencies, as with businesses and nonprofits, ethics are vital to conducting business—with agency efficiency, effectiveness, and public trust on the line.

Consider what happens when employees leave work early or stay out for extended lunches without making up the time. Although extra-long lunches might seem trivial at first glance, the cumulative impact across an organization can be dramatic. Take, for example, an organization with 5,000 employees who earn $50,000 per year on average. If each employee takes a lunch break and reports back to work 15 to 30 minutes late one time per month, the financial impact on the organization is anywhere from $360,000 to $720,000 per year. Put another way, the money paid for lost work equals the salaries of 7.5 to 15 full-time employees.

For management, lost productivity due to employees missing work clearly can have quantifiable ramifications for the efficiency and effectiveness of service delivery.

And at the individual level, employees should be aware that the actions described in this scenario constitute timecard fraud.

Within the transportation community, when someone makes the wrong ethical choice, the effects can be especially severe given that available fiscal resources are unable to meet growing demands. All transportation professionals represent the first line of defense in ensuring program integrity and upholding public trust. These professionals include contracting officers and their technical representatives, cooperative agreements and grants administrators, construction managers, compliance officers, contractor representatives, and others who carry out vital programs involving construction and maintenance of the Nation's roadways.

"Across the spectrum of highway finance, from purchasing to contracting, to general oversight responsibilities directed at improving public safety and protecting the public trust, the most important element of America's infrastructure is the public's confidence in it and in those responsible for it," says Federal Highway Administrator Thomas J. Madison, Jr., "The actions of those charged with directing America's infrastructure—from capacity enhancements to bridge inspections to megaprojects from coast to coast—must be ethical and worthy of the public's trust."

ERC's President Patricia J. Harned agrees: "The most important asset of government is public trust. Citizens believe that elected officials, political appointees, and career public servants are acting in their best interest. When public trust erodes, government effectiveness is hindered."

From the perspective of the U.S. Department of Transportation's (USDOT) Office of Inspector General (OIG), having a strong culture of ethics in the workplace is central to promoting program effectiveness and preventing or stopping fraud, waste, abuse, and other irregularities. An effective ethics program and culture is needed to combat potential issues before they cause harm to agencies, their public images, or the important services they provide. Effective internal controls and oversight mechanisms must be in place to detect and reduce instances of fraud that prohibit the transportation community from accomplishing its goals. The issue comes down to this: *Everyone* is responsible for maintaining program integrity and, in turn, the public trust.

About OIG

The U.S. Department of Transportation's (USDOT) Office of Inspector General (OIG) views trust as the cornerstone of public service. Fraud and abuse harm Federal, State, and local efforts to provide the safe and efficient transportation systems essential to the Nation's economic vitality, ability to compete in a global economy, and, most important, each citizen's quality of life. Fraud and abuse also hinder efforts to fulfill the Federal Highway Administration's mission to improve mobility on U.S. highways through national leadership, innovation, and program delivery.

OIG serves the USDOT mission and the public primarily by conducting audits and investigations. However, another tool is its fraud awareness outreach efforts, which include educating members of the transportation community about basic ethical principles and standards and how they can foster a culture of high ethical standards.

Ethical Behavior Is the Law

Merriam-Webster's Online Dictionary defines ethics as "the discipline dealing with what is good and bad and with moral duty and obligation," and, "the principles of conduct governing an individual or a group."

In the Federal Government, employees swear an oath to the American people to conduct themselves in an ethical manner. In fact, title 5 of the Code of Federal Regulations, part 2635, sets the standards of ethical conduct for employees of the executive branch. The first sentence reads, "Public service is a public trust. Each employee has a responsibility to the United States Government and its citizens to place loyalty to the Constitution, laws, and ethical principles above private gain." Similar requirements exist at the State and local levels, and for many private organizations.

Basic Ethical Principles And Standards

At the Federal level, two core concepts underlie ethical principles and standards. Executive branch employees, including those in OIG, hold their positions as a public trust. They fulfill that trust by adhering to general principles of ethical conduct and specific ethical standards. These principles broadly define the obligations of public service and relate to issues such as maintaining financial responsibility, soliciting or accepting gifts, and engaging in outside employment.

Underlying these principles are two core concepts: Employees shall not use public office for private gain, and employees shall act impartially and not give preferential treatment to any private organization or individual.

In addition, employees must strive to avoid any action that would create even the *appearance* that they are violating the law or ethical standards. By observing these general principles and specific standards, agency employees help ensure that U.S. citizens can have confidence in the integrity of Government programs and operations.

Making the Wrong Choices

Ethical lapses by individuals in critical positions do occur, sometimes resulting in scandals that significantly

Shown here is the forfeited home of one of two university professors who embezzled nearly $1 million in FHWA cooperative agreement funds.

USDOT

TDOT

TDOT reimbursed FHWA for $20 million used to construct this parking garage near FedExForum Arena in Memphis after OIG discovered that a contractor associated with the Memphis Grizzlies was operating the garage for profit rather than providing free or discounted parking for transit customers.

undermine public confidence in the Government. An example of this that still reverberates is the 2004 conflict-of-interest conviction of a former top Air Force procurement officer and a Boeing executive, involving a major U.S. Department of Defense (DoD) contract for tanker aircraft.

In 2003, the media reported that a DoD official had helped negotiate a plan to lease Boeing 767 commercial jets to the Air Force for use as aerial refueling tankers. The DoD official and Boeing's former chief financial officer were fired after internal investigations found they had violated DoD and company policies, respectively. The Boeing executive had communicated with the DoD official about possible employment with Boeing while the official still worked for the Air Force and before she recused herself from involvement with Boeing contracts. Both tried to conceal their misconduct.

USDOT also has seen its share of cases involving conflicts of interest, fraud, improper financial activities, and other ethical lapses. Although the following examples are not government employee ethical issues, the examples do point to making the wrong ethical choices when doing business with the Government. Regardless of whether government employees or contractors make the wrong ethical choices, the backlash can affect public confidence in Government.

For example, in one case investigated by OIG, two university engineering professors embezzled nearly $1 million in Federal Highway Administration (FHWA) cooperative agreement funds for a program administered by the university. The 4-year embezzlement scheme was uncovered after a university official became suspicious about invoices they submitted for payment. The university official identified a potential conflict of interest in contracting with a firm controlled and partially owned by one of the professors and brought these discrepancies to the attention of FHWA, which referred the matter to OIG for investigation.

The professors had been entrusted as directors to manage the program on behalf of the university; therefore, contracting with the aforementioned firm was an ethical violation and a conflict of interest. In the end, the university agreed to reimburse the Government more than $1.8 million for the overcharges plus penalties. The professors pled guilty to the embezzlement charges, were sentenced to 43 months in prison, and had to pay restitution of nearly $1 million.

In another case, OIG, in concert with the Tennessee Department of Transportation (TDOT) Office of Internal Audit, investigated the construction and operation of a 1,700-space parking garage sponsored by the city of Memphis and built with TDOT oversight. The facility was constructed using $20 million in Federal funds near the FedExForum Arena in Memphis, home of the National Basketball Association's Grizzlies basketball team. The FHWA-approved plan called for using the garage to provide free or discounted parking for transit passengers, with the proceeds helping to manage and maintain the garage. Instead, OIG found that a contractor associated with the Grizzlies was using the garage for profit. Subsequently, TDOT reimbursed FHWA for its $20 million.

OIG investigations also have revealed ethical lapses involving construction of the Central Artery/Tunnel Project in Boston, known as the Big Dig. These investigations, in collaboration with FHWA, the Federal Bureau of Investigation (FBI), U.S. Attorneys Office, Massachusetts State Police, and Massachusetts Office of the Attorney General, not only touched on misrepresentation and lapses in judgment but the ultimate effects of such actions—the compromise of the traveling public's safety.

Four long-running cases were recently settled when several Big Dig contractors, including the project's contract management consultant and 24 section design consultants (and their insurers), agreed to pay more than $500 million to resolve certain criminal and civil liabilities in conjunction with the investigations. In part, these liabilities include a ceiling tile collapse in the I–90 connector tunnel that killed a motorist and injured her husband, and defects in the slurry walls in the I–93 Thomas P. "Tip" O'Neill, Jr. Tunnel,

This photo from 2004 shows vehicles rushing along the I–90 underground tunnel in Boston, part of the Central Artery/Tunnel Project. In 2007, an epoxy adhesive failure caused ceiling tiles to dislodge and fall in the tunnel, killing a motorist and initiating an OIG investigation.

Massachusetts Turnpike Authority

Shown here is the ceiling of the I–90 tunnel, part of Boston's Central Artery/ Tunnel Project, after an epoxy bolt adhesive failure.

This anchor bolt dislodged from the ceiling of the I–90 tunnel when the epoxy adhesive failed.

Massachusetts Turnpike Authority

which caused a severe leak breach that allowed water and sand to flow into the tunnel at 300 gallons per minute, significantly impeding traffic. In addition to the monetary penalty, the settlement agreement holds the management consultant accountable for any future catastrophic events occurring in the next 10 years and requires it to enact corporate compliance programs designed to prevent similar conduct on public construction projects.

OIG also has investigated cases that, though not criminal, pose serious administrative implications for both USDOT employees and the Department. For example, in one USDOT agency, a senior executive attended social functions paid for by a contractor that was the executive's previous employer. Employees perceived the executive as pressuring subordinates to award more than $1.1 million in contract task orders to the contractor for a strategic plan and marketing-related services. The executive was disciplined and no longer works for USDOT.

In another case, a program manager steered a $465,000 subcontract for financial analysis-related services to a firm owned and controlled by a household member. The manager resigned her USDOT position without any rights of appeal after being served with a notice of proposed removal citing violations of conflict of interest and misuse of Government position standards. The manager's senior executive (an associate administrator) was subsequently reprimanded for failing to ensure that a conflict of interest was avoided or cured, neglecting to take appropriate actions, and failing to notify ethics officials after becoming aware of the conflict of interest violations.

"The OIG enters the picture after unethical conduct has occurred in cases like this," says USDOT Inspector General Calvin L. Scovel. "We assist by investigating the allegations and reporting the facts to decisionmakers so they can determine what action to take. While dealing properly with allegations is imperative, taking steps to prevent unethical conduct is critical, and management must lead by example."

Making the Right Choices

Such situations can occur in any organization. Although the preceding examples highlight cases where the wrong choices were made, many examples exist where USDOT employees and others have made the right choices to uphold the public trust by demonstrating high ethical standards.

For instance, an inspector with the Missouri Department of Transportation alerted a resident engineer that the supervisors of a paving crew were switching asphalt cores to fraudulently earn quality bonuses under at least two Federal-aid contracts in St. Louis. After corroborating the allegation by surreptitiously marking quality control core locations with special paint, the engineer, materials supervisor, and district engineer referred the matter through their headquarters to OIG. The investigation resulted in payment of a $200,000 civil settlement and firing of the paving crew chief and supervisor responsible for the misconduct.

Another example of making the right choice includes a Connecticut Department of Transportation (ConnDOT) inspector and resident engineer assigned to a reconstruction project on I–95 in Bridgeport. The inspector noted that a concrete supplier had delivered precast concrete catch basins only a day after ConnDOT had approved the custom design, including a framework of reinforcing steel. Precast concrete structures normally must cure for at least a week before shipment.

The inspector reported the discrepancy to the resident engineer, who noted handwritten markings on one of the catch basins indicating that it was standard stock, not a custom product. The engineer directed destructive testing on one of the catch basins and found no reinforcing steel. After twice blaming the matter on truckers who "mistakenly" loaded the wrong stock, the concrete supplier finally admitted his

A construction defect in slurry wall panel E0-45 in the I–93 northbound tunnel of the Central Artery/Tunnel Project led to this major water infiltration.

Massachusetts Turnpike Authority

USDOT

Shown here are asphalt core samples that OIG special agents seized as evidence from a project on Page Avenue in St. Louis, MO. The double-marked cores (top left) were from the job site, whereas the nondouble-marked cores (lower right) were allegedly substituted.

company had falsely certified that it provided materials meeting contract specifications. The supplier was suspended from the State's prequalification program, had to identify and replace deficient structures at a substantial cost, and paid $500,000 in criminal and civil penalties. This case also illustrates concerns that can arise about safety of the traveling public and the service life of transportation facilities when taxpayers do not get what they pay for as a result of unethical behavior.

How to Create an Ethical Workforce Culture

- Demonstrate top management commitment to a culture of ethics
- Establish an ethics officer or team
- Distribute written rules, policies, and procedures
- Train employees to recognize and make ethical decisions
- Ensure a supportive climate for ethical conduct
- Monitor and audit conduct, both formally and informally
- Maintain whistleblower channels and policies
- Respond immediately to misconduct
- Abide by and enforce disciplinary policy consistently and fairly
- Reward acts of integrity and ethical decisions

Ensuring High Ethical Standards

First and foremost, OIG encourages reporting unethical conduct to help foster high ethical standards. Cases involving choices on both ends of the ethical spectrum clearly exist, yet OIG experience reveals that individuals who are aware of misconduct often do not report it because they believe no corrective action will be taken, worry about confidentiality, fear retaliation by supervisors and coworkers, or are uncertain about whom to contact.

Managers and supervisors need to be aware of and address these reasons for not reporting unethical conduct. For example, all transportation staff should know how and to whom to report allegations of fraud, waste, abuse, and other irregularities. But knowledge or awareness is not enough. Agencies need to continually promote and reinforce ethical standards to help safeguard against lapses in integrity across the myriad of transportation programs and activities. To its credit, in June 2008, USDOT responded to this challenge by instituting enhanced annual ethics training programs for all acquisition and grants management personnel across the Department. When announcing this new program, USDOT Deputy Secretary Thomas J. Barrett said, "As good stewards of the taxpayers' dollar, we must strive daily to conduct the Department's business in a manner that promotes the integrity of the acquisition and grants management activities processes and in a manner that is above ethical reproach."

Experts agree that prevention and deterrence of ethical lapses in any organization depend on the effectiveness of internal controls and oversight and a robust ethics awareness and training program. However, no ethics program will be a panacea; ethical conduct ultimately derives from individual moral judgment. Yet it is imperative that government employees, grantees, and contractors alike actively foster a culture of ethical behavior.

Fostering an ethical environment starts with the tone at the top. Management must lead by personal example and recognize that building and maintaining an ethics-oriented culture involves more than simply requiring employees to submit annual financial disclosure reports and certify that they have completed briefings on standards of ethical conduct. To further instill ethical values and expectations through heightened awareness, ethics programs need to be multifaceted, with increased attention given to employees involved in awarding and administering contracts, cooperative agreements, and grants—the areas where OIG has found that fraud and ethical misconduct are most likely to occur.

In addition to the U.S. Office of Government Ethics regulations (5 CFR Part 2635, et seq.), agencies might consider the following in their ethics programs:

- Recurrent expressions of commitment by the organization's senior leadership to include stressing the importance of maintaining an arms-length relationship with contractors and grantees and avoiding even the appearance of impropriety.
- Periodic case study discussions of instances where ethics violations occurred, as well as discussions of hypothetical scenarios.
- Thorough review and followup on financial disclosure filings to identify potential problems.
- Consideration of contractor and grantee participation in the program.

Computer and Web-based ethics training, especially interactive

ConnDOT

A State inspector destructively tests a precast concrete catch basin to determine whether it meets contract specifications for a reconstruction project on I–95 in Bridgeport, CT.

courses including questionnaires with automated feedback, is beneficial and efficient but not a substitute for personal interaction between agency ethics officials and employees. Moreover, ethics officials should routinely consult with *their* ethics advisers—for the Federal level, this is the Office of Government Ethics—as a resource for training, best practices, advisory opinions, and updates on statutory and other requirements.

In addition to enhancing ethics awareness and training, working with OIG and other transportation oversight providers can help strengthen internal ethics programs and improve fraud detection and prevention. Organizations should invest time and resources to prevent and detect fraud and misconduct proactively; establish and use trusted reporting methods, such as anonymous hotlines; and mandate antifraud and ethics training and reward employees not only for meeting financial goals but for displaying outstanding ethical behavior.

Government agencies, grantees, and contractors should pursue suspected ethics violations aggressively, whether potentially criminal, civil, or administrative, and refer them quickly to the appropriate authority for possible investigation. This approach includes allegations of fraud related to false claims, false statements, cost mischargings, kickbacks, and bribes and gratuities. Many cases involve aberrant behavior by employees who deceive both the Government and their companies. Problem behavior should be addressed immediately.

State inspectors noticed handwritten markings on this concrete catch basin indicating that it was standard stock, not a custom product as required by the contract.

CommDOT

Methods for Reporting Possible Ethics Violations

USDOT and OIG learn about ethical lapses in a variety of ways but most often through tips. To report situations that could result in fraud, waste, abuse, or other irregularities to the OIG, use one of the following methods:

- Online Complaint Form: https://www.oig.dot.gov/hotlineform.jsp
- Telephone: 800–424–9071
- Fax: 540–373–2090
- E-mail: hotline@oig.dot.gov
- Mail: USDOT Inspector General
  P.O. Box 708
  Fredericksburg, VA 22404-0708

USDOT and OIG encourage those who contact the hotline to identify themselves in case questions arise as the allegations are evaluated; however, anonymous tips also are welcome.

USDOT employees and employees of USDOT contractors who report fraud are typically entitled by Federal law to whistleblower protection from employer attempts at reprisal. Many States provide similar protections. For more information, see the U.S. Office of Special Counsel's Web site at www.osc.gov.

Note: The OIG Hotline is obligated to expeditiously forward all safety-related complaints to USDOT's safety regulatory agencies for action, as appropriate.

Finally, to heighten deterrence, managers need to take strong disciplinary and other actions when ethical lapses occur and also do the following:

- Find and remove bad actors before they engage in major fraud.
- Identify root causes and systemic weaknesses.
- Strengthen internal controls to prevent recurrences.
- Realize that self-reporting of known ethical lapses or fraud, along with an effective compliance program, can mitigate civil and criminal liability.
- Continuously communicate expectations.

Closing Thoughts

The consequences of ethical lapses and fraud can be grave: project delays, increased costs, loss of public trust, and loss of life and injuries when safety is involved. *Everyone* associated with the transportation community is responsible for ensuring the integrity of the Nation's transportation programs and activities. Vigilance and effective internal controls and oversight are essential to mitigating the extent to which fraud and abuse involving transportation programs cheat U.S. taxpayers and erode public confidence in the transportation system. Strong ethical awareness is the cornerstone of effective vigilance and oversight.

Most professionals in the transportation community—government employees, grantees, and contractors alike—behave ethically and work diligently to ensure taxpayers have the best transportation system possible for their tax dollars. OIG investigations, however, have consistently demonstrated the need for continual reinforcement of ethical standards to prevent breaches of integrity that result from government and private sector employees losing their ethical compass. Vigilance is critical. What are *you* doing to promote an ethical culture in your workplace?

Jim H. Crumpacker is OIG's director for National Investigative Programs and Operations. He leads a staff responsible for monitoring contract procurement and grant fraud and safety-related investigative efforts, and for supporting criminal and civil investigative operations nationwide. He also manages OIG's Computer Crimes Unit. He previously served as a director in OIG's surface transportation and maritime audit group (2003–2005) and as the Inspector General's representative to the U.S. Department of Homeland Security to handle relief and recovery oversight following the 2005 gulf coast hurricanes. Prior to joining USDOT, he worked for the U.S. Postal Service OIG and U.S. Air Force Audit Agency. He is a colonel in the U.S. Air Force Reserve and has been a federally credentialed special agent with the U.S. Air Force Office of Special Investigations for more than 16 years. Crumpacker holds a bachelor's degree in business administration in finance and a master's degree in public administration. He is also a Certified Internal Auditor® and Certified Fraud Examiner.

Electronic Freight Management

USDOT's new EFM system provides an accurate, efficient, and inexpensive Web-based method of tracking the transport of goods across the world.

by Randy W. Butler

In 2007, the United States set a record year for freight transport, moving more than $2.5 trillion in goods into and out of the country. The Office of Freight Management and Operations within the U.S. Department of Transportation (USDOT) expects freight transport to grow rapidly in years to come as markets continue to open around the world. Moving freight across the globe is complex, involving processes for exchange of information among multiple partners and agencies as well as transfer of goods between modes of transportation.

Most of the Nation's freight is shipped using a collection of organizations—referred to as supply chain partners—that include shippers and cargo handlers. Most of these partners do not communicate electronically, resulting in delays, lost goods, and reduced efficiencies along the way. Accurate, efficient, and inexpensive tracking methods—essential for both port security and business success—are limited.

American businesses that seek information on their freight as it is being shipped have two choices: contract with private, end-to-end shippers that track freight using proprietary systems, or ship through a patchwork of mostly unconnected companies and modes, foreign and American, that pass responsibility and paperwork along with the freight.

Private shipping companies, such as FedEx® and UPS™, use their own customized systems to track the status and location of their shipments as they cross the globe, resulting in accurate information from origin to destination. Shipping companies like these use electronic technologies to identify and track the movement of goods and to provide required information to government agencies as cargo crosses international, national, and State borders. Tracking freight electronically offers a variety of benefits: efficiencies and cost savings from continuous tracking, maximizations of carrying capacities, and more accurate forecasts of arrival and pickup times. Plus, no effort, fuel, or space is wasted.

Recognizing the value of improved freight tracking, USDOT launched the Electronic Freight Management (EFM) research initiative in 2006. The EFM initiative is addressing the challenge of tracking freight accurately and in real time. Specifically, the EFM system focuses on developing an open, Internet-based system for tracking freight as it moves across borders and from mode to mode, without the expense of engaging proprietary shipping services.

The EFM system, now entering its third and final phase of evaluation and deployment, will be available in 2009 as a Web-based tool accessible to all businesses and shippers in the

(Above) The new EFM system is designed to track freight traffic accurately, efficiently, and inexpensively as shipments are carried in containers like the ones shown here.

United States or abroad to configure their supply chains and connect with their supply chain partners. An end-to-end system for tracking shipping information, EFM mimics the efficiencies of proprietary, integrated systems for enhanced tracking and security connecting all supply chain partners in the information loop rather than parsing information out on an individual, piecemeal basis. The EFM system provides near real-time information sharing—tracking the movement of goods from the time of order to the manufacturer to the time of delivery.

The Research Challenge

The EFM research has three main goals: (1) improving the efficiency and productivity of the freight logistics supply chain through the electronic exchange of shipping information from origin to destination, (2) improving data accuracy throughout the process, and (3) minimizing costs for shippers and supply chain partners.

Another goal of the initiative is to design a system to ensure that data are entered *once* but used *many times*, thereby eliminating data transcription errors. The EFM system aims to help companies replace paper trails with electronic information, freeing up human resources that were previously devoted to manual data entry. Data captured once can be shared with all parties engaged in particular shipments. Further, authorized supply chain partners will be able to use the system without having to replace or overhaul their existing information systems.

In developing the EFM system, USDOT and its partners are incorporating innovative e-business concepts, facilitating process coordination and information sharing through public-private collaboration. Further, the EFM team is working directly with the freight transportation industry to identify opportunities for implementing the tool.

The Research Roadmap

In 2006, USDOT defined three phases for the EFM initiative, with completion scheduled for 2010. To date, funding for EFM from the most recent transportation legislation—the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—totals $7 million. The first phase, funded at $1.4 million and covering system development, standards, and architecture, is complete. Phase 2, an operational test of the system, was funded at $4 million and finished successfully in December 2007.

Phase 3, funded at $1 million and completed in fall 2008, involves an independent evaluation of the EFM system. The last set of activities under phase 3 will focus on industry adoption, with $0.6 million allocated for targeting central manufacturing and trucking locations, such as Columbus, OH, and Kansas City, MO, for early adoption. The goal is for 50 trade development zones to adopt the system by 2010.

An important tool for promoting EFM is a Web site developed for shippers, www.efm.us.com. The Web site is an expansion of the prototype deployed in phase 2 for the operational test. The new, expanded site includes a capability for cost-benefit analyses for shippers interested in using EFM.

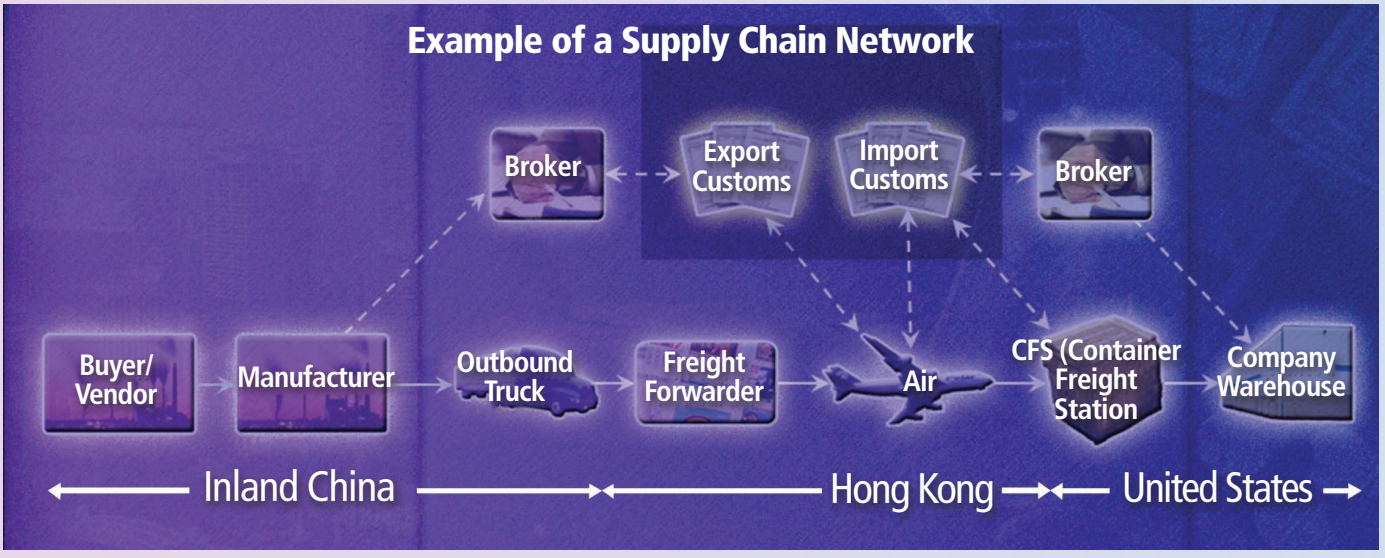
System Infrastructure And Security

Typically, freight movements are supported by point-to-point communications, either paper-based or electronic. Using the Internet to make data broadly available to any authorized and authenticated user in real time is key to improving the

International Trade Growth Facts and Figures

- The value of exports and imports rose in constant dollars from $2.1 trillion in 2002 to $2.5 trillion in 2007, and the tonnage increased from 1.7 billion to nearly 2.0 billion in the same period.
- The value of merchandize trade has grown sixteen-fold in inflation-adjusted terms since 1951.
- The sum of exports and imports in 2035 is expected to reach 3.5 billion tons worth $12.3 trillion in 2002 dollars.

Source: USDOT, Federal Highway Administration, Freight Facts and Figures 2008, Washington, DC.



This diagram shows a schematic example of a typical supply chain network showing the modes and phases needed for a specific shipment from China to the United States. *Source: Battelle Memorial Institute.*

Homepage banner from the new EFM Web site. *Source: Battelle Memorial Institute.*

exchange of information along a supply chain and, ultimately, making freight transportation networks more efficient and secure. This type of data exchange provides buyers and shippers (owners of the supply chain) with visibility into their supply chains, which enables them to see where the goods are located and provides critical status information.

Freight supply chain partners are likely to have a broad mix of technology infrastructures and application platforms that are usually incompatible and unable to share data. To help solve this problem, the EFM initiative developed an Internet-based system that provides an open platform (or architecture) built on data standards that enable partners to exchange needed information seamlessly and dynamically. The system features standard (off-the-shelf) technology and Web components already used successfully in a variety of industries. In addition, the EFM format offers uniform access to existing, customized database formats, computing platform independence, and customizable services.

The openness of the EFM architecture lends itself to the constantly changing business environments of supply chain transactions. By using this format, supply chain partners can automate daily business interactions and streamline business processes. Diverse technology systems can communicate with each other in a service-oriented architecture (SOA), and new Web services can be implemented incrementally, leveraging existing information technology assets by reusing them for EFM.

No central data repository needs to be deployed as part of the EFM concept; instead, cross-agency messaging is accomplished on demand and in real time. To facilitate customer use, EFM will contain a function similar to the familiar yellow pages of phone books, standardizing the directories of information on Web services and listing their capabilities, location, input requirements, and expected output or service performed. Supply chain partners will be able to use these entries to learn the specifics of communicating with other partners' Web services.

Information sharing within EFM is implemented with strict data security requirements. Secure encryption and digital certificates are part of the system to ensure that information is sent and received only between authorized partners, is not corrupted along the way, and is complete and unadulterated. This type of security allows multiple supply chain partners to share data within the system with the confidence that only authorized partners will have access to sensitive business data.

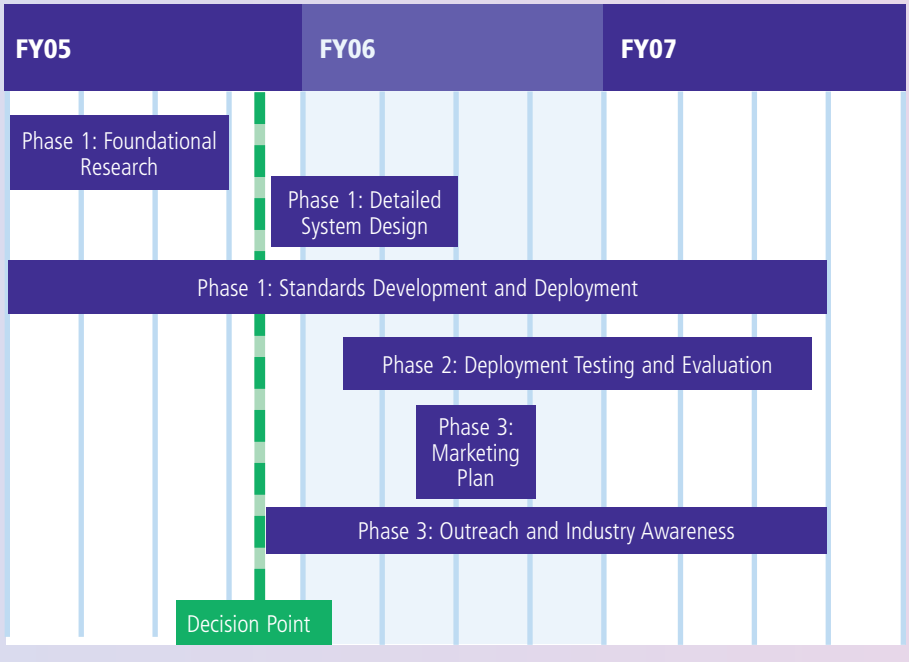
According to Jon Bosak, distinguished engineer at Sun Microsystems™, EFM is "the most compelling illustration of the concept of service-oriented architectures in practical use that I've ever seen. It's the most useful combination of SOA and electronic documents [Universal Business Language, or UBL] that I can imagine."

Testing the EFM Prototype

In 2007, the USDOT Intelligent Transportation Systems (ITS) Joint Program Office funded and helped launch phase 2 of the EFM research, an operational test of the prototype to evaluate the system in a real-world, international air-freight supply chain. The Federal Highway Administration's (FHWA) Office of Freight Management and Operations, in conjunction with the ITS Joint Program Office, conducted the 6-month test in partnership with Limited Brands, located in Columbus, OH, and its supply chain partners in Columbus and Hong Kong.

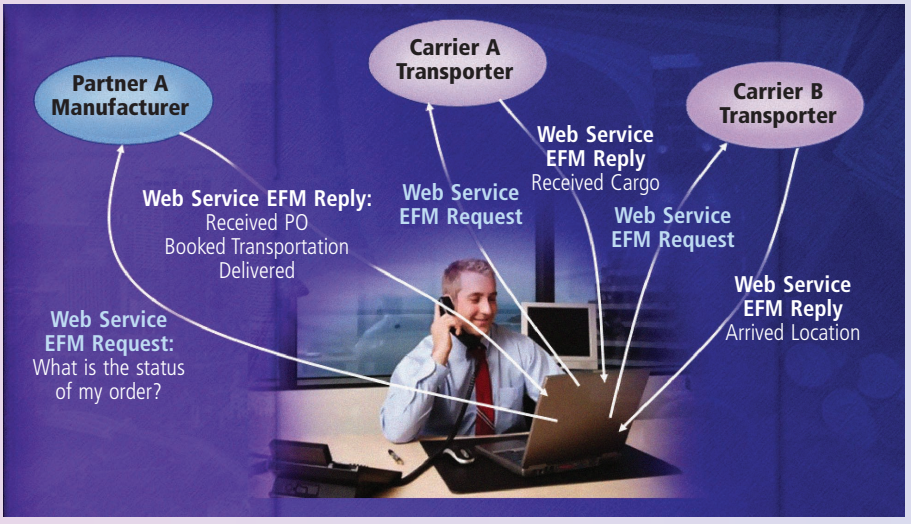
During this testing period, the ITS Joint Program Office tracked more than 850 completed freight consignments using the EFM technologies. Early conclusions from the prototype testing indicate that the EFM system improved freight tracking across the board.

Major Phases of the EFM Initiative



This timeline shows the primary phases of the EFM initiative. *Source: FHWA.*

Dynamic Data Sharing Under EFM



As this diagram illustrates, all partners throughout the supply chain can access real-time information throughout the freight transportation cycle.
Source: Battelle Memorial Institute.

Timeliness of the freight release process. Goods were released 6 to 24 hours in advance of normal release through an Automated Air Manifest System.

Status information. The system provided near real-time automated status reports containing all supply chain events. Previously, the reports either were unavailable or required significant manual effort to prepare.

Timeliness of supply chain data. The system provided downstream partners earlier access to data on purchases, booking, and tendering. Users could access status data on demand that previously were available only from manually prepared daily prealerts and status reports. The advance shipment notice was available either 6 hours or up to 1 day earlier than current practices allow. Shipment status information was available to the broker 4 to 6 hours earlier.

Data quality on the supply chain. The prototype test revealed few errors in data entry because of reduced occasions for data entry and no rekeying of data on the supply chain, making it easier for partners to respond to discrepancies. The system proved to be more accurate than existing systems, requiring fewer corrections of errors.

In addition, the EFM initiative successfully initiated the first steps in developing internationally accepted standards. Without standards, the system cannot be adopted globally. The EFM operational test validated the exchange protocols and standards, and the EFM team now is working with national and international standards organizations to coordinate the many components involved in producing data standards.

Value of the EFM System

Phase 3's independent evaluation, conducted by Battelle Memorial Institute, assessed a series of factors:

System usefulness. Will the system allow for improved tracking of goods?

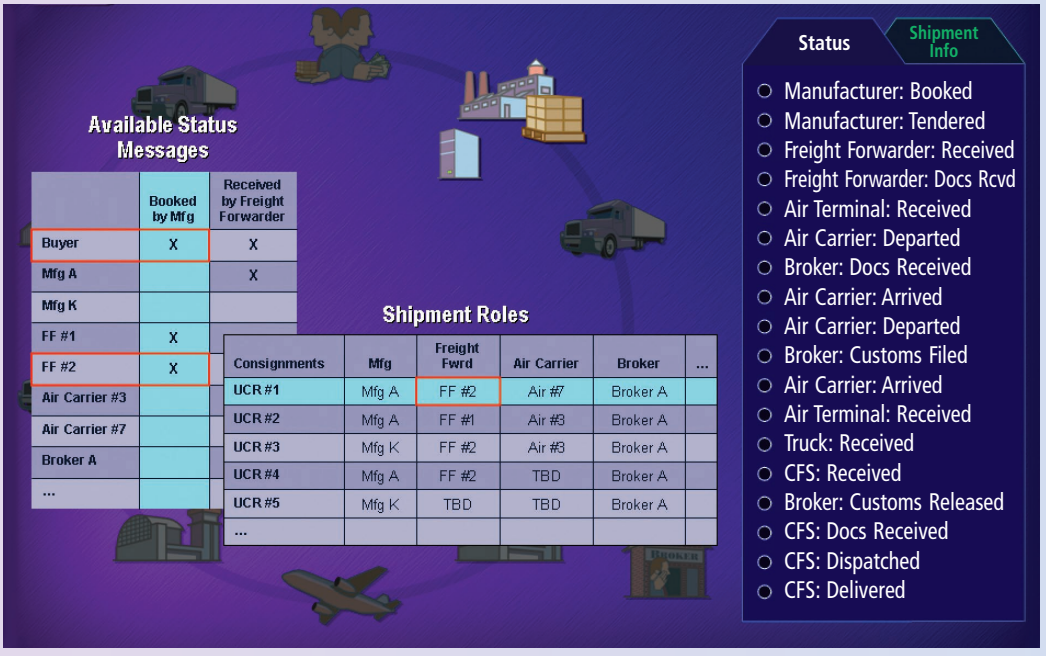
Cargo visibility. Will government agencies find value in the improved visibility—obtaining information on the number of containers coming into their community in advance—so they can use the information to improve transportation planning, safety, and security?

Supply chain and logistics performance. Will the system improve productivity? Will it help measure or forecast congestion and pollution reduction?

Deployment and scalability. Are the standards appropriate and supportive of industry requirements? What are the costs and benefits? How well does the system work when expanded to include additional users?

The independent evaluators have conducted a rigorous analysis of the EFM test to validate

View of the EFM Web Application



This diagram shows the status of goods movement for all partners in the supply chain.
Source: Battelle Memorial Institute.

the benefits and also have cross-tabulated findings from other industry survey organizations, such as Capgemini and Aberdeen, to support the overall findings.

The benefits of this system will include the following:

Value to businesses and related decisionmakers. Companies can set up the nonproprietary system for a fraction of the traditional cost of proprietary or customized tracking systems. Companies enhance their reputation for reliability, security, and just-in-time service. Carriers do not put trucks on the road until cargo arrival and clearance are assured. Costs go down, efficiencies improve, unnecessary truck trips are avoided, and competition increases.

Rick DeShone, president of Codeworks, LLC, says, "EFM offers supply chain partners increased shipment visibility by producing real-time status information by as much as 48 hours over current systems in place. Once the infrastructure is in place, the cost of adding visibility for new partners is a fraction of the cost of traditional systems."

Improved security. For companies that order goods from around the world, more reliable tracking and tighter transfer will improve security conditions for freight coming into the country from abroad.

Value to the economy. Shorter duration and more reliable shipping will stimulate freight productivity and enhance transportation efficiency. The EFM system will produce improved security, transparency, and reliability for the Nation's supply chain, and increased cost savings and competitiveness to individual businesses.

Value to the environment. Truckers will be able to schedule pickups to maximize their loads, thus improving fuel efficiency. They will be able to plan their trips to avoid idling at docks or distribution centers while waiting for late arrivals. Overall, less fuel will be consumed and fewer greenhouse gases will be emitted from tailpipes.

Value to the transportation infrastructure. Fewer but fuller loads translate into fewer vehicles on U.S. roads, decreasing congestion and improving the flow of critical goods and services that support the Nation's economy and productivity.

Test Highlights

The test showed that the EFM system:

- Reduced total travel time from Hong Kong to Columbus, OH, from 96 hours to 82 hours (14 percent) within the 6-month test period.
- Saved 10 hours and $259 per day in labor costs across the entire supply chain by reducing paperwork (more than 75 percent per shipment).
- Improved data accuracy at the container freight station by 25 percent, reducing the number of office trips to verify data or fill data gaps.
- Reduced data entry errors by eliminating manual data entry by multiple partners and thus reducing rekeying errors.
- Customs brokers could process 18 percent more shipments per week, in part due to earlier document processing because of data availability. Earlier access to data would speed the processing time of a shipment by an average of 16 percent.
- Provided the supply chain partners with an efficient, secure, and reliable tracking system without requiring changes in existing business processes or purchase of new technologies or systems. EFM is not a new standalone system but is integrated into existing legacy systems.

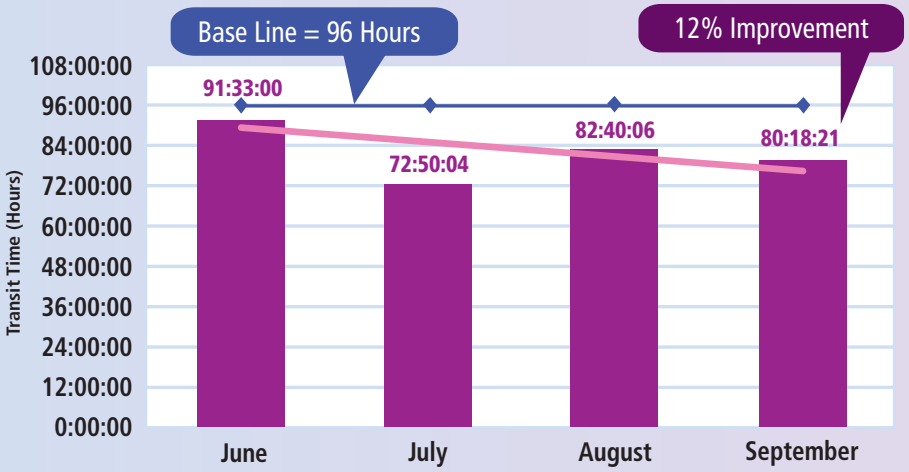
Source: www.efm.us.com.

As companies implement the EFM system, the benefits will include driving down deployment costs, increasing participation, and enlarging the total flow of benefits. These types of technologies, if implemented with international standards, can play a major role in expanding the effective capacity of the Nation's transportation system, improving efficiencies and reliability, and enhancing shipment integrity, which will contribute to national productivity and prosperity.

Randy W. Butler joined FHWA in 2003 as a transportation specialist on the Operation and Technology Team. Prior to that, Butler completed 35 years in the private sector managing freight transportation operations, engineering, customer service, business process reengineering, information systems, and project management supporting freight movement. His education includes a B.S. in engineering technology from the University of Memphis, an M.B.A. and M.S. in management information systems from Bellevue University, and an M.A. in transportation policy, operations, and logistics from George Mason University. Currently, Butler is pursuing a Ph.D. in information technology at George Mason University.

For more information, see www.efm.us.com or http://projects.battelle.org/fih/Files/EFM_White_Paper_Final_APR06.pdf or contact Randy W. Butler at 202-366-9215 or randy.butler@dot.gov.

Transit Time From Hong Kong to Container Freight Station



Using the EFM system, the transit time from Hong Kong to the container station was reduced by 12 percent. *Source: FHWA.*

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

Transportation Workers Face Tougher Drug Testing

As of August 25, 2008, USDOT requires that all mandatory drug tests for the Nation's transportation workers be analyzed for tampering. The rule covers the approximately 12.1 million transportation employers, safety-sensitive transportation employees, collectors, labs, and medical review officers.

Under the previous regulations, labs had the option of testing urine samples for signs of cheating, but with the implementation of the new rule, every specimen must be tested for possible adulterants and urine substitutes. All collectors are required to adopt new procedures to prevent tampering with drug tests, such as checking employees for items designed specifically to cheat the test. New procedures also are required for monitoring all tests for workers who return to their jobs after previously failing a drug test.

The change in policy is an effort by USDOT to ensure that everyone working in transportation is able to do their jobs as safely as possible. According to USDOT, tests determined to have invalid results will be treated the same as a refusal to be tested by an employee who admits to tampering with his or her test.

Technical News

Improving Pavement Performance With the Asphalt Mixture Performance Tester

A pooled fund study launched by the Federal Highway Administration (FHWA) offers State transportation agencies the opportunity to obtain and learn to use the new asphalt mixture performance tester (AMPT) to evaluate Superpave mixtures. The AMPT is a computer-controlled hydraulic testing machine that subjects an asphalt mixture specimen to cyclic loading that mimics traffic loading and then measures the deformation of the mixture to assess performance. The system offers an improved method of predicting the performance of Superpave mixes, including the likelihood of rutting.

The 3-year study, Implementation of the Asphalt Mixture Performance Tester (AMPT) for Superpave Validation, has the following objectives:

- Purchase and deliver the AMPT for highway agencies.
- Provide training in using the AMPT to perform proposed American Association of State Highway and Transportation Officials (AASHTO) standard practices for measuring dynamic modulus and flow number and developing dynamic modulus master curves.
- Evaluate the nationwide implementation and use of the AMPT to assess performance over a range of climatic conditions, materials, and structures.

Shown here, the new asphalt mixture performance tester is used to evaluate Superpave mixtures.

The average cost of an AMPT ranges from $75,000 to nearly $90,000. The pooled fund study will provide a means for participants to purchase the device at a discounted rate. In addition, the study will provide technical support and implementation assistance, involve development of a National Highway Institute training course for the AMPT, and cover travel and course expenses for two representatives from each participating agency.

To learn more about or join the pooled fund study, contact Audrey Copeland at 202-493-0341 or audrey.copeland@dot.gov. More information is also available at www.pooledfund.org/projectdetails.asp?id=405&status=4.

Book Introduces Quieter Pavements To a Broad Audience

The Little Book of Quieter Pavements (FHWA-IF-08-004), recently released by FHWA, introduces readers to the basics of sound, traffic noise, tire-pavement noise, and strategies for designing and building quieter pavements. The book answers basic questions such as "How do we hear?" and "What is a decibel?" and "How does sound travel?" as well as more complex questions regarding mechanisms that produce noise, such as tires on pavement.

One section of the book focuses on methods for measuring noise, such as wayside, source, and invehicle noise measurements. The authors also examine how pavement texture, porosity, and stiffness affect noise. The final section profiles the pros and cons of asphalt and concrete from a noise perspective and describes criteria to consider when choosing a quieter pavement.

The book is accompanied by MP3 (digital audio) files, so readers can play samples of various pavement noises where noted in the book. This interactive approach helps readers—even those outside the transportation field—understand the factors that contribute to highway noise and the latest strategies for creating quieter pavements.

The Little Book of Quieter Pavements *is available from the FHWA Research and Technology Product Distribution Center by calling 301–577–0818 or e-mailing report.center@fhwa.dot.gov.*

Public Information and Information Exchange

Busy Interstates Receive $11 Million For Truck Parking

Two of the Nation's busiest interstates, I–95 and I–5, recently received more than $5 million each in Federal support for innovative strategies to assist truckers looking for parking along these congested routes.

The Truck Parking Facilities program uses intelligent transportation systems to provide truckers with real-time information on available parking. The technology monitors and transmits parking updates to truckers, enabling them to find vacant spots without having to look for parking while driving. Truckers can plan their stops according to the information transmitted to them and prevent traffic problems that could occur from slowing down to search for parking.

FHWA selected I–95 and I–5 for the Truck Parking Facilities program based on a corridor-wide approach to addressing congestion along interstates heavily used to transport freight. The average daily truck traffic on both I–95 and I–5 is more than 10,000, and the two corridors represent 10 percent of total interstate truck traffic.

For more information, visit www.fhwa.dot.gov /safetealu/factsheets/truckpark.htm.

Guides Highlight Pedestrian Safety in Neighborhoods and at Transit Stops

In a continuing effort to reduce pedestrian injuries and fatalities, FHWA released two guides—one to help residents and community groups make their communities safer for walking, and another to assist transit agencies in creating safer environments for pedestrians accessing transit stops.

A Resident's Guide for Creating Safe and Walkable Communities (FHWA-SA-07-017) includes numerous resources, such as factsheets, worksheets, sample materials, and references, to assist residents in planning pedestrian safety projects and addressing issues that affect walking conditions. The guide also highlights several successful community-oriented pedestrian projects and programs. A walkable community makes it easy and safe to walk to stores and services, encourages pedestrian activity, expands transportation options, and serves people with different levels of mobility.

The *Pedestrian Safety Guide for Transit Agencies* (FHWA-SA-07-016) addresses the need for transit agencies to ensure that conditions are safe for pedestrians traveling to and from transit stops. The transit guide, like the resident's guide, provides a wealth of resources, including background information, references, case studies, and descriptions of engineering, education, and enforcement treatments and programs. The guide also emphasizes the importance of working with State and local transportation agencies, municipalities, and road users to solve pedestrian safety issues.

To order or download a copy of either guide, visit http://safety.fhwa.dot.gov/ped_bike/ped/index.htm.

USDOT Selects University of Minnesota as Clearinghouse for Rural Road Safety

Aiming to reduce the number of injuries and deaths on the Nation's rural roads, USDOT recently announced the establishment of a new national clearinghouse for information on ways to make rural roads safer. Created by the University of Minnesota's Center for Excellence in Rural Safety, the clearinghouse is part of a new national strategy to bring resources and new technologies to improving rural road safety.

The primary responsibility of the clearinghouse is to collect lessons learned by researchers and transportation officials who are successfully combating fatalities on rural roads and to distribute the information to transportation officials and first responders across the country.

The clearinghouse is a component of USDOT's Rural Safety Initiative, which aims to help States and communities develop safety strategies to eliminate drivers' risk on rural roads. The effort addresses five key goals: safer drivers, better roads, smarter roads, better trained emergency responders, and improved outreach and partnerships.

For more information, visit www.dot.gov/affairs /ruralsafety. To view the clearinghouse resources, please visit www.ruralsafety.umn.edu/clearinghouse /index.html.

Transportation Public-Private Partnerships Hit Record High

According to a USDOT report released in July 2008, the number of public-private partnerships (PPPs) has increased significantly in recent years and continues to climb. The report, *Innovation Wave: An Update on the Burgeoning Private Sector Role in U.S. Highway and Transit Infrastructure*, states that more than 20 major highway and transit projects currently are being conducted in partnership with the private sector in the United States. The number of partnerships completed over the last 3 years is higher than in any other comparable time period in history.

Transportation officials credit the increase to innovative approaches to financing and managing transportation, which are "increasingly attractive compared to traditional tax and spend methods," one USDOT official says. The report shows that States and localities can reduce project costs, accelerate project delivery, and transfer risks to the private sector while also protecting public sector interests through concession agreements. The report also asserts that the increase in use of PPPs is because of their proven track record for relieving congestion and encouraging infrastructure development.

The report is available for download at www.fhwa .dot.gov/reports/pppwave/ppp_innovation_wave.pdf.

California Transportation Projects Receive Excellence Awards

In August 2008, Caltrans selected 14 transportation projects to receive Excellence in Transportation Awards. The annual awards recognize excellence in design, construction, traffic operations, maintenance, planning, and improvements throughout the State.

By region, the categories and winners are as follows: *North Coast:* historic preservation/cultural enhancement, Fernbridge Emergency Bridge Rail Replacement; transportation innovations, Pacific Coast Bike Route Modified Delineator Demonstration Project; transportation-related facilities, "Hole in the Hammond" Multi-Use Trail Extension; and seismic, Noyo River Bridge. *Sacramento:* environment, Highway 149 Environmental Impact Mitigation Project; safety, Highway at Excelsior Road Safety Improvements; maintenance (operations or equipment), Pavement Recycling–Cold in Place; context sensitive solutions, Sutter–Highway 99 Sound Wall; and public awareness, 2007 Construction Rollout. *San Diego:* intermodal transportation, I–5, International Friendship Plaza; system operations, SR–76 at Olive Hill Road Intersection Improvements; and highway (urban), New SR–125 and SR–54 Segments (South Bay Expressway). *Orange County:* highway (rural), SR–133/Laguna Canyon Road. *San Francisco Bay area:* major structures, Benicia-Martinez Bridge.

Caltrans

AASHTO Video Advances Study on Lane-Departure Crashes

AASHTO recently released a short informational video to promote its report *Driving Down Lane-Departure Crashes*. The video, featuring AASHTO President Pete Rahn, draws attention to the report and the steps State departments of transportation (DOTs) are taking to reduce crashes due to cars leaving their lanes.

AASHTO, posted on www.youtube.com

AASTHO released a short online video to promote its report *Driving Down Lane-Departure Crashes*.

Rahn, who is also director of the Missouri Department of Transportation, offers his perspective on the challenges State DOTs are facing. "Over half of the fatalities…on our roads today occur when vehicles are leaving their lanes," Rahn says in the video. However, he remains optimistic about the progress made so far, adding, "We have seen, in the last 2 years, a cumulative reduction in fatalities on our roadways [in Missouri] that has exceeded 25 percent."

The report outlines a number of relatively low-cost, systematic approaches—such as rumble strips and enhanced pavement markings—that many State DOTs are implementing to help prevent deaths from collisions that occur when a vehicle veers from its lane. The report and video are part of a plan to reduce the death toll on U.S. highways by half within two decades, a goal set by AASHTO in October 2007.

To view the video, visit www.youtube.com/aashtovideo. For more information, visit www.transportation.org. To order the report, see https://bookstore.transportation.org/item_details.aspx?ID=1216.

AASHTO

Strategic Plan Released for Infrastructure Research and Development

The FHWA Office of Infrastructure Research and Development (R&D) released a strategic plan to guide all aspects of the office's research and technology initiatives for the next 10 to 15 years. The plan, *Highways of the Future—A Strategic Plan for Highway Infrastructure Research and Development*, provides direction for future infrastructure research and a framework to support the reauthorization efforts in advance of the expiration of authority under the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

The plan focuses on several challenges faced by highway agencies in meeting the increased demands placed on the country's highway infrastructure. Challenges include the need to extend the service life of existing highway infrastructure; to build, rehabilitate, and rebuild infrastructure; and to address the mobility challenges posed by natural and manmade hazards by designing and constructing less vulnerable infrastructure and employing rapid restoration techniques to restore functionality after a disaster occurs.

According to the plan, the FHWA Office of Infrastructure R&D will conduct research to develop knowledge, guidelines, analytical and physical tools, and test methods and procedures that enable the delivery of safe, environmentally friendly, long-lasting, disaster-resilient, and cost-effective highway infrastructure. Another goal is to support end user efforts to maintain and manage the Nation's infrastructure more effectively based on the realities of funding needs versus constraints. The office also will provide specialized technical assistance to address infrastructure issues of national importance requiring research capabilities and technical expertise available at the FHWA Turner-Fairbank Highway Research Center in McLean, VA.

To view or download the plan, visit www.tfhrc.gov /infrastructure/pubs/08068.htm.

Minnesota Updates Guidance on Public Involvement

The Minnesota Department of Transportation (Mn/DOT), in conjunction with the FHWA Minnesota Division and the Center for Transportation Studies at the University of Minnesota, recently updated its guidance materials for public and stakeholder participation in transportation projects. The updated components include a new Web site, a training curriculum that addresses managing effective public involvement, and a revised version of Mn/DOT's public involvement guidance "Hear Every Voice: A Guide to Public Involvement at Mn/DOT."

The goal of the "Hear Every Voice" initiative is to provide an opportunity for both internal and external partners to learn more about the Mn/DOT approach to public involvement and ways to identify and balance stakeholder values and objectives during project development. The initiative offers state-of-the-art, comprehensive curricula and skill building in best practices. Training is supported with online tools and resources to provide real-world implementation opportunities and achieve maximum efficiency.

Mn/DOT launched the initiative in 1999 to address State laws and Federal mandates requiring public involvement in statewide planning and project development. The updates reflect additional 2005 SAFETEA-LU requirements and current best practices from the International Association of Public Participation. The new Web site and technical training opportunities will help implement the public involvement process throughout the State.

For more information, visit www.dot.state.mn.us /planning/publicinvolvement.

Mn/DOT

Personnel

FHWA Employees Judycki and Gee Receive Notable Awards

Two FHWA employees, King W. Gee, associate administrator for infrastructure, and Dennis C. Judycki, former (retired) associate administrator for research, development, and technology, recently received the Presidential Rank Award of Meritorious Executive. The President gives this award annually to leaders who consistently demonstrate strength, integrity, industry, and a relentless commitment to public service.

Gee received the recognition for his visionary leadership and ongoing contributions to advancing FHWA's goals of improving safety, mobility, global connectivity, and security. Judycki received the recognition for providing national leadership and direction in coordinating and implementing the FHWA and USDOT Exploratory Advanced Research Program within the transportation research and technology community.

In addition, Judycki also received the 2008 Roy W. Crum Distinguished Service Award from the Transportation Research Board for his outstanding leadership in research management. As FHWA's chief manager, overseer, and champion of research, Judycki worked to enhance national programs and develop partnerships in highway research and technology, reaching out to stakeholders and promoting implementation of innovative research results.

Internet Watch

by Alicia Sindlinger

New Tool Introduced by the Environmental Competency Building Program

Developing and maintaining the knowledge and expertise of transportation and environmental professionals is essential to delivering environmentally sustainable transportation programs. With this in mind, the Federal Highway Administration (FHWA) created the Environmental Competency Building (ECB) Program to support professional development opportunities in the transportation and environmental disciplines. In line with its mission, the ECB Program recently released the Competency Navigator, an online resource designed to assist transportation professionals in identifying recommended competencies for key environmental and technical areas and linking them to specific tools and resources related to those competencies.

The Competency Navigator was developed by a Steering Committee of transportation and environmental stakeholders, including representatives from FHWA and State departments of transportation, private environmental and transportation consultants, and other Federal agency liaisons. Working from core competencies identified by FHWA, the committee looked at a broad audience—from top-level managers to staff working in the field—to determine the range of competencies that come into play.

According to Committee Chair Lamar Smith of FHWA's Office of Project Development and Environmental Review, the group focused on identifying the skills needed to ensure that workers are equipped to handle the demands of their positions. "There was recognition that training and professional development at a personal and institutional level are extremely important, and that college does not always provide the training needed to do the job," Smith says. Further, he adds, the committee sees the tool as a means to point out areas where training and development are needed and to help influence the marketplace to fill those gaps.

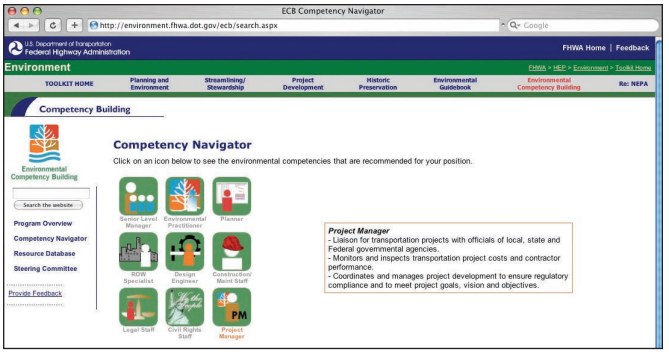
Environmental Competency

Environmental competency refers to the knowledge and skills needed to perform specific technical or legal obligations in the transportation planning and delivery processes. Delivering a sustainable transportation program involves a range of knowledge for transportation planning, from ecology and biology to historic preservation. The degree of competency required often varies by discipline and professional role.

The Competency Navigator helps individuals in different disciplines find tailored recommendations for the degree of proficiency they should strive to achieve. Specifically, the tool customizes its recommendations around nine disciplines or roles in the transportation and environmental professions, including senior level managers, project managers, environmental specialists, planners, right-of-way specialists, design engineers, construction and maintenance staff, legal staff, and civil rights professionals.

Using the Competency Navigator

When a user selects his or her profession, the Navigator generates a specific list of environmental competencies



The main page of the Competency Navigator features graphic icons representative of various positions.

recommended for that role. The competencies then are sorted into three levels of understanding specific to that profession. The levels of understanding are (1) *awareness*, or a general familiarity with the subject area or skill; (2) *general understanding*, or the ability to apply broad knowledge to situations likely to be encountered and to recognize significant deviations; and (3) *technical proficiency*, or demonstration of a high degree of knowledge or skill in a particular area. Recommendations for *technical proficiency* are reserved for the competencies that are most critical to the role of the user.

Classification by level of understanding tailors the opportunity for professional development and discipline-specific resources and information to individual users. For example, if a project manager were to use the Competency Navigator, he or she would find that it recommends *awareness* of issues such as coastal resources and sampling techniques and procedures, *general understanding* of issues such as community impact analysis and land use, and the most critical *technical proficiency* for issues such as context sensitive solutions and interagency contact and coordination.

In addition to helping professionals identify key areas of environmental competencies important to their jobs, the Competency Navigator serves as a centralized source of up-to-date resources and information organized in a user-friendly manner. Currently, the Navigator includes more than 1,100 listings of trainings, seminars, workshops, research materials, and other Web-based resources, and will be updated continually with new information. "The Navigator is a mechanism, a resource, and a way to assist us in meeting the overall goals of the ECB Program," Smith says.

FHWA encourages environmental and transportation professionals to explore the tool and provide feedback on its functionality and format, and the quality of information available. According to Smith, the committee is relying on the transportation industry to "help us build it, maintain it, and keep it going."

To use the Competency Navigator, visit http://environment.fhwa.dot.gov/ecb/search.aspx. For more information on the ECB Program, visit www.environment.fhwa.dot.gov/ecb/index.aspx or contact Lamar Smith at 202-366-8994 or lamar.smith@dot.gov.

Alicia Sindlinger is a contributing editor for PUBLIC ROADS.

Training Update

NATIONAL HIGHWAY INSTITUTE

by Stacy Stottmeister

Building Freight Professional Capacity

As freight volumes continue to grow on the national transportation network, a skilled and knowledgeable workforce at all levels of transportation policy development and project level planning is crucial to improving the productivity, safety, and security of freight movement. To meet these needs, the Federal Highway Administration's (FHWA) National Highway Institute (NHI) offers a growing catalog of freight-related courses.

Freight Courses

FHWA designed the following five NHI courses to build a broad range of professional capacity in freight issues.

- *Integrating Freight in the Transportation Planning Process (FHWA-NHI-139006).* This entry level Web-based training (WBT) provides information on freight transportation dynamics, identifies key stakeholders, and discusses issues that affect the integration of freight considerations into transportation planning. *Note: This WBT replaces the instructor-led (FHWA-NHI-139001) version of the course.*
- *Advanced Freight Planning (FHWA-NHI-139003).* This course expands on topics covered in the course Integrating Freight in the Transportation Planning Process and presents techniques and strategies for planning, programming, and implementing freight transportation projects and plans.
- *Uses of Multimodal Freight Forecasting in Transportation Planning (FHWA-NHI-139002).* Forecasting freight traffic is a complex task that uses different data sources and analytical tools than those used to forecast passenger travel. This course provides an overview of freight forecasting and techniques for meeting facility-specific needs.
- *Linking Freight to Planning and the Environment (FHWA-NHI-139005).* This course focuses on integrating freight and environmental considerations throughout the planning, programming, and project development processes.
- *Principles of Effective Commercial Motor Vehicle (CMV) Size and Weight Enforcement (FHWA-NHI-139004).* This course provides information on enforcing Federal size and weight regulations and writing and evaluating State enforcement plans and annual certifications.

For more information on scheduled sessions, visit the NHI Web site.

Certificate of Accomplishment in Freight Management and Operations

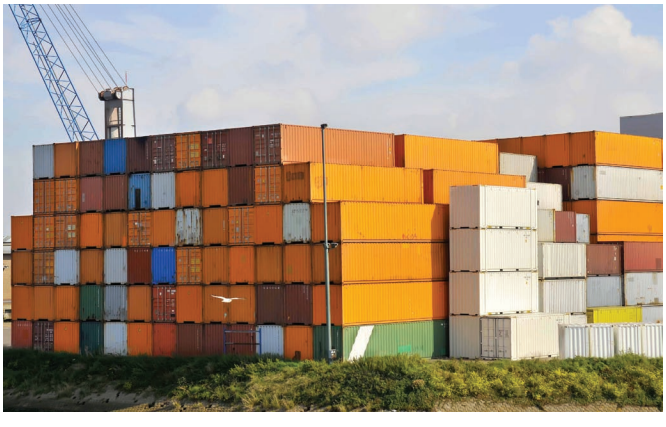
NHI offers a certificate of accomplishment to recognize individuals who have successfully completed and achieved passing grades in four key freight courses: Integrating Freight in the Transportation Planning Process, Advanced Freight Planning, Uses of Multimodal Freight Forecasting in Transportation Planning, and Linking Freight to Planning and the Environment. When bundled together, these complementary NHI courses enhance an individual's depth and breadth of knowledge and expertise in the area of freight transportation.

For more information on NHI courses or certificates of accomplishment, visit the NHI Web site at www.nhi.fhwa.dot.gov. To schedule a session, contact the NHI Scheduler at nhitraining@dot.gov.

Other Professional Learning and Capacity Building Opportunities

In addition to the NHI courses, the Office of Freight Management and Operations' Freight Professional Development (FPD) Program offers a broad range of professional capacity building opportunities:

- *Engaging the Private Sector in Freight Planning Workshop.* This workshop focuses on establishing and sustaining relationships with key private sector stakeholders. It reviews strategies and techniques to initiate public-private sector cooperation, identifies key private sector stakeholders, and suggests ways to improve and sustain communication. Successful approaches implemented at several State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) are discussed.
- *Financing Multimodal Freight Improvements Workshops.* These workshops provide information on funding and financing multimodal freight improvement projects. The workshops present examples of successful freight project financing by State DOTs, MPOs, local agencies, and the private sector.
- *"Talking Freight" Seminar Series.* Seminars held monthly through Web conferencing provide a convenient way to learn about the latest trends, issues, tools, and noteworthy practices in freight transportation.



Shutterstock ©E.G. Pors

Stacks of shipping containers at this port are among the signs of the increasing demand for freight planning in the United States. New FHWA and NHI professional development opportunities, including training, help transportation officials hone the skills necessary to manage the growth in freight movement.

- *Freight Peer-to-Peer (P2P) Program.* This program facilitates information sharing between public sector freight transportation professionals on topics of their choosing. This program offers agencies the opportunity to work one-on-one with technical experts to develop specific skills or address particular challenges.
- *Freight Planning Listserv.* This listserv provides a venue for public and private sector freight transportation professionals to exchange information on innovative strategies and best practices in freight planning at the State and metropolitan area levels.

"Enabling public sector transportation professionals to develop the skills and knowledge needed to fully integrate freight movement into our transportation system development and operations is the objective of FHWA's FPD Program," says Tony Furst, director of the Office of Freight Management and Operations. "By providing these opportunities, we are giving them the tools they need to meet freight transportation challenges safely and effectively."

For more information on the FPD Program, visit http://ops.fhwa.dot.gov/freight/fpd or contact Carol Keenan at 202-366-6993 or carol.keenan@fhwa.dot.gov. For questions about the Freight P2P Program, contact Kate Quinn at 202-366-4241 or e-mail freightpeerexchange@fhwa.dot.gov.

Stacy Stottmeister is a contractor for NHI.

Reporting Changes of Address

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

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    Martha M. Soneira, Editor-in-Chief
    October 1, 2008

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.

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

Address requests for items available from the R&T Product Distribution Center to:

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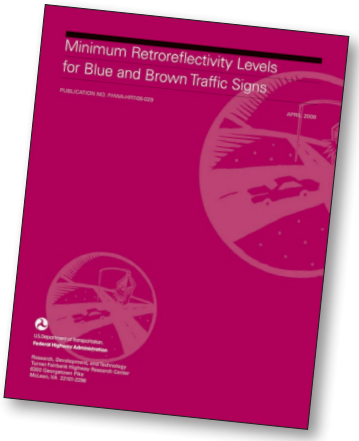
Federal Highway Administration
9701 Philadelphia Court, Unit Q
Lanham, MD 20706
Telephone: 301–577–0818
Fax: 301–577–1421
E-mail: report.center@fhwa.dot.gov

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

Minimum Retroreflectivity Levels For Blue and Brown Traffic Signs
Publication No. FHWA-HRT-08-029

In 2003, FHWA published research recommendations for minimum maintained retroreflectivity (MR) levels for most traffic signs but excluded white-on-blue and white-on-brown signs. The 2003 recommendations for MR levels were based on conditions representing dark, rural environments. This new report describes the research activities and findings related to the development of recommendations for MR levels for white-on-blue and white-on-brown signs. The report also includes recommendations from an investigation related to MR levels needed for complex visual conditions, including glare from oncoming headlamps and fixed roadway lighting.



The researchers used a summary of pertinent literature to develop an experimental plan to produce luminance thresholds that could be used with a previously developed analytical model to develop a set of recommendations for MR levels for white-on-blue and white-on-brown signs. The researchers integrated the results for these signs into one table with the current set of MR levels and consolidated both legend and symbol signs into the same recommendations because of similar requirements for luminance thresholds.

The report is available at www.tfhrc.gov/safety/pubs/08029/index.htm and from NTIS under order number PB2008111445. Printed copies also are available from FHWA's R&T Product Distribution Center.

Safety Evaluation of Increasing Retroreflectivity Of STOP Signs
Publication No. FHWA-HRT-08-041

FHWA organized a pooled fund study involving 26 States to evaluate low-cost safety strategies as part of FHWA's strategic highway safety effort. One of the strategies evaluated was STOP signs with increased retroreflectivity. This strategy aims to reduce the frequency of crashes related to drivers being unaware of STOP signs at unsignalized intersections.

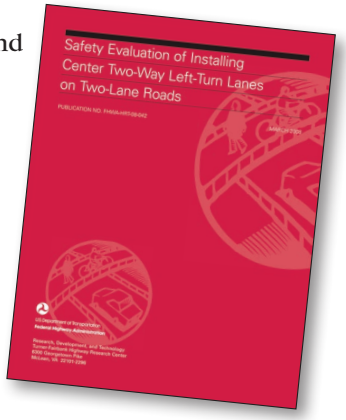
Researchers obtained geometric, traffic, and crash data at unsignalized intersections from 231 sites in Connecticut and 108 sites in South Carolina. In each case, the researchers installed STOP signs with increased retroreflectivity. Next, the researchers incorporated Empirical Bayes (EB) methods (a statistical calculation) in a before-and-after analysis to determine the safety effectiveness of increasing the sign retroreflectivity.

The study revealed a statistically significant reduction in rear-end crashes in South Carolina. Based on the results of the disaggregate analysis, the researchers found reductions in crashes at three-legged intersections and intersections with low approach volumes. The analysis also indicated a slight reduction in nighttime- and injury-related crashes in Connecticut and South Carolina, but the results were not statistically significant. The researchers determined that a much larger sample size would be needed to detect a significant effect in these types of crashes.

Given the low cost of installing STOP signs with increased retroreflectivity, even with conservative assumptions, only a modest reduction in crashes is needed to justify their use. Therefore, this strategy has the potential to reduce crashes cost effectively, particularly at lower volume intersections.

The report is available at www.tfhrc.gov/safety/pubs/08041/index.htm and from NTIS under order number PB2008110098.

Safety Evaluation of Installing Center Two-Way Left-Turn Lanes on Two-Lane Roads
Publication No. FHWA-HRT-08-042



Another strategy chosen to be evaluated in FHWA's pooled fund study was the installation of center two-way left-turn lanes on two-lane roads. The goal of this strategy is to reduce the frequency of crashes involving a turning vehicle, which could be classified as head-on or rear-end crashes.

Researchers obtained geometric, traffic, and crash data for 78 sites in North Carolina, 34.9 kilometers, km (21.7 miles, mi) of roadway; 10 sites in Illinois, 9.7 km (6.0 mi); 31 sites in California, 10.95 km (6.8 mi); and 25 sites in Arkansas, 21.25 km (13.2 mi). The researchers incorporated EB methods in a before-and-after analysis to determine the safety effectiveness of installing the two-way left-turn lanes. The study revealed a statistically significant reduction in total and rear-end crashes in each of the States where the installations were evaluated. Rural installations proved to be more effective in reducing crashes than urban ones.

The researchers concluded that installations of these types of lanes can be a cost-effective treatment for two-lane rural roads, especially those with a high frequency of rear-end collisions involving a vehicle trying to make a turn.

The report is available at www.tfhrc.gov/safety/pubs/08042/index.htm and from NTIS under order number PB2008110100.

Safety Evaluation of STOP AHEAD Pavement Markings
Publication No. FHWA-HRT-08-043

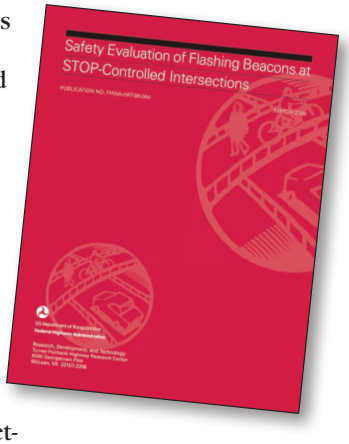
This report on STOP AHEAD pavement markings was part of an FHWA pooled fund study to evaluate low-cost safety strategies to reduce the frequency of crashes related to drivers being unaware of stop control at unsignalized intersections.

Researchers obtained geometric, traffic, and crash data at unsignalized intersections for 8 sites in Arkansas, 9 sites in Maryland, and 158 sites in Minnesota. To account for potential selection bias and regression to the mean, the researchers conducted an EB before-and-after analysis to determine the safety effectiveness of installing STOP AHEAD pavement markings. Results of the aggregate analysis indicate a statistically significant reduction in total crashes at the Arkansas and Maryland sites. The combined aggregate analysis for these two States indicates a reduction of at least 15 percent in total crashes. The study also revealed a statistically significant reduction in right-angle and rear-end crashes at the Arkansas sites. Injury crashes dropped as well in Arkansas and Maryland, as the study found a statistically significant crash reduction of 10 percent for the two States combined. The results for Minnesota were not included in the main analysis but support the conclusion that this strategy is effective in improving safety.

The disaggregate analysis indicated that crash reductions are highly significant at three-legged intersections and significantly greater than reductions at four-legged intersections. The strategy also proved more effective at intersections with all-way stop-control (AWSC). Given the low cost of this strategy, even with conservative assumptions, only a modest reduction in crashes is needed to justify its use. Based on the estimated safety effectiveness of STOP AHEAD pavement markings, the researchers concluded that the necessary crash reduction to obtain a 2:1 benefit-cost ratio is easily achieved. Therefore, this strategy has the potential to reduce crashes cost effectively at unsignalized intersections, particularly at three-legged and AWSC intersections.

The report is available at www.tfhrc.gov/safety/pubs/08043/index.htm and from NTIS under order number PB2008111181.

Safety Evaluation of Flashing Beacons at STOP-Controlled Intersections
Publication No. FHWA-HRT-08-044



This report on flashing beacons was part of an FHWA pooled fund study. Researchers studied three types of flashing beacons—intersection control beacons, beacons mounted on STOP signs, and actuated beacons—at stop-controlled intersections. The purpose of this strategy is to reduce the frequency of crashes related to drivers being unaware of stop signs at unsignalized intersections.

Researchers obtained geometric, traffic, and crash data at stop-controlled intersections for 64 sites in North Carolina and 42 sites in South Carolina. The researchers incorporated EB methods in a before-and-after analysis to determine the safety effectiveness of installing flashing beacons, while accounting for potential selection bias and regression-to-the-mean effects.

Overall, installation of flashing beacons in North Carolina resulted in statistically significant reductions in total, angle, and injury plus fatal crashes. The intersections in South Carolina experienced little change following the introduction of flashing beacons. The combined results from both States support that an angle crash reduction of 13 percent and an injury and fatal crash reduction of 10 percent can be expected. The economic analysis based on the combined results for angle and nonangle crashes from both States indicates that standard flashing beacons and some of the actuated ones (that is, the less expensive beacons) are economically justified, but that a benefit-cost ratio of 2:1 might not be achievable for the more expensive beacon types.

The report is available at www.tfhrc.gov/safety/pubs/08044/index.htm and from NTIS under order number PB2008111182.

Conferences/Special Events Calendar

Date	Conference	Sponsors	Location	Contact
April 30–May 2, 2009	Structures Congress 2009	American Society of Civil Engineers (ASCE) and ASCE's Structural Engineering Institute	Austin, TX	Barbara L. Hickman 703-295-6307 bhickman@asce.org Jim Rossberg jrossberg@asce.org www.SEInstitute.org
May 3–6, 2009	Annual Subcommittee on Information Systems Meeting	American Association of State Highway and Transportation Officials (AASHTO)	Seattle, WA	Grant Rodeheaver Washington State DOT 360-705-7601 rodeheg@wsdot.wa.gov www.transportation.org/meetings/189.aspx
June 1–3, 2009	ITS America's Annual Meeting & Exposition	ITS America	Fort Washington, MD	Edgar Martinez 202-484-4847 info@itsa.org or emartinez@itsa.org www.itsa.org/annualmeeting.html
June 14–17, 2009	International Bridge Conference	Engineers' Society of Western Pennsylvania	Pittsburgh, PA	Conor McGarvey 412-261-0710, ext. 11 c.mcgarvey@eswp.com www.eswp.com/bridge
June 22–24, 2009	15th International Conference on Urban Transport and the Environment	Wessex Institute of Technology Transactions on the Built Environment	Bologna, Italy	Irene Moreno +44 (0) 238 0293223 imoreno@wessex.ac.uk www2.wessex.ac.uk/09-conferences/urban-transport-2009.html
June 29–July 2, 2009	8th International Conference on the Bearing Capacity of Roads, Railways, and Airfields	ASCE, Association of American Railroads, Center of Excellence for Airport Technology, Federal Aviation Administration, Illinois Center for Transportation, Illinois Department of Transportation, Transportation Research Board, University of Illinois at Urbana-Champaign, University of Illinois Railroad Engineering Program, USDOT	Champaign, IL	Erol Tutumluer 217-333-8637 BCR2AConference@ad.uiuc.edu www.bcr2a.org
July 13–15, 2009	9th International Symposium on Fiber Reinforced Polymer Reinforcement for Concrete Structures (FRPRCS-9)	American Concrete Institute, Construction Institute, Engineers Australia, International Institute for FRP in Construction, ISIS Canada Research Network, and Japan Concrete Institute	Sydney, Australia	FRPRCS-9 Symposium Secretariat +61 2 9368 1200 frprcs9@iceaustralia.com www.iceaustralia.com/frprcs9
July 16–18, 2009	18th International Symposium on Transportation and Traffic Theory (ISTTT18)	Commerce and Economic Development Bureau, The Government of The Hong Kong Special Administrative Region, and The Croucher Foundation	Hong Kong	ISTTT18 Secretary 011 (852) 2766-6070 secretary@isttt18.org www.isttt18.org

Materials Overcharging

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