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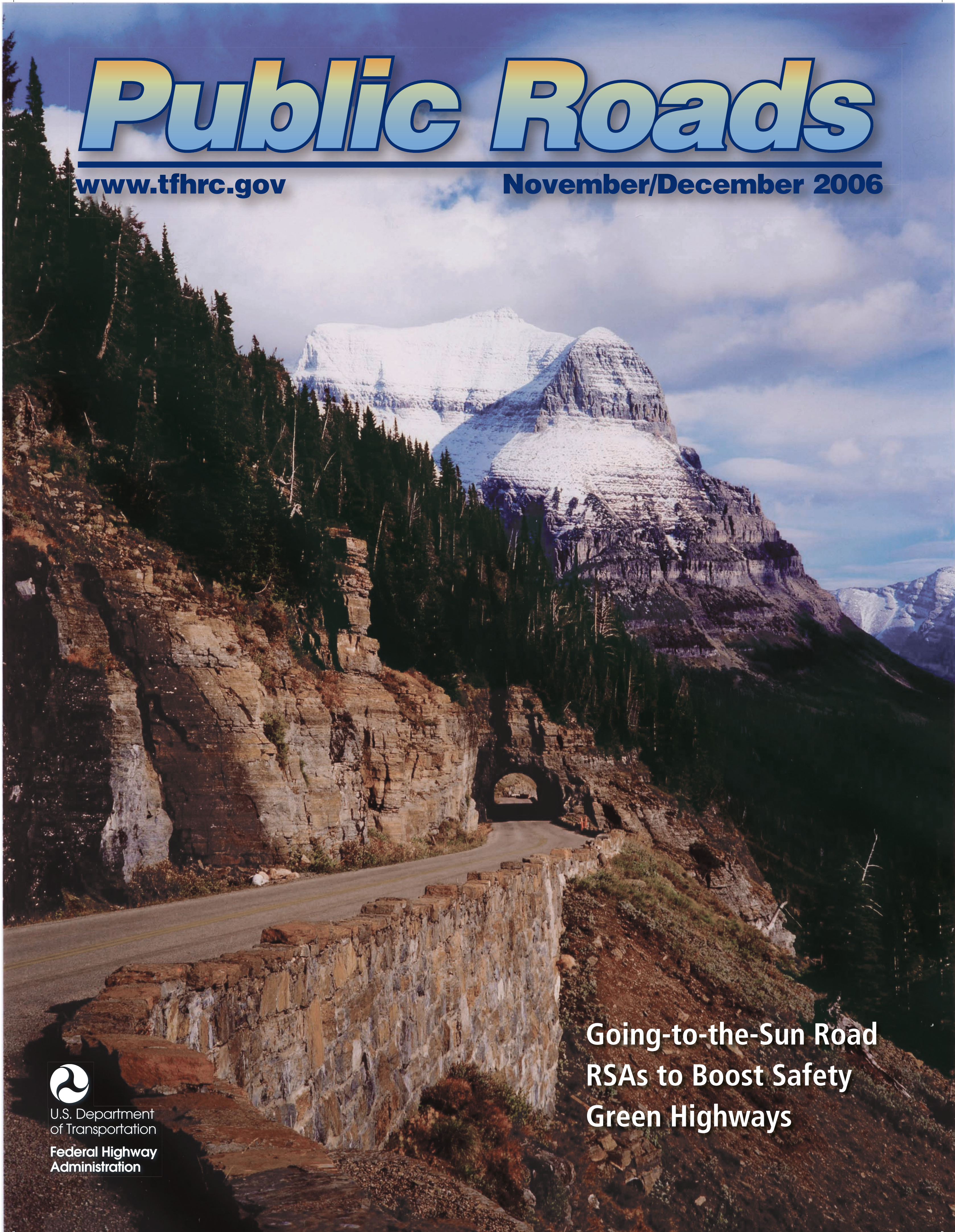

Going-to-the-Sun Road

RSAs to Boost Safety

Green Highways

U.S. Department of Transportation

Federal Highway Administration

Public Roads

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

November/December 2006 www.tfhrc.gov Vol. 70, No.3

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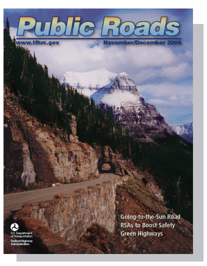

Front cover—The Going-to-the-Sun Road in Montana's Glacier National Park descends toward the East Side Tunnel with Going-to-the-Sun Mountain, the landmark for which the road was named, in the background. The National Park Service and FHWA are collaborating on a multiyear program to rehabilitate this historic highway. *Photo copyright: E.B. Gilliland, www.glacierparkphotography.com or ebg@glacierparkphotography.com.*

Back cover—When the Going-to-the-Sun Road in Montana's Glacier National Park was completed in 1933, highcountry scenes like this unnamed cascade became more accessible to tourists and backcountry travelers. After 73 years of service, the alpine highway is now undergoing a major rehabilitation. *Photo copyright: E.B. Gilliland, www.glacierparkphotography.com or ebg@glacierparkphotography.com.*

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

Guest Editorial

The Law and Beyond

On June 29, 1956, President Dwight D. Eisenhower signed into law the Federal-Aid Highway Act of 1956, launching the Interstate construction program. On July 14, 1955, just a year earlier, he had signed the Air Pollution Control Act of 1955, initiating a new era in Federal environmental law.

Over the next 50 years, as the interstate system grew, so did the body of law regulating the environment. In 1969, the National Environmental Policy Act was passed, and the Long Island Expressway Viaduct was rebuilt; in 1973, the Endangered Species Act was passed, and the Eisenhower/Johnson Memorial Tunnel was completed; in 1977 the Clean Water Act was passed, and a year later the Vail Pass was completed. At last count, more than 60 environmental laws now apply to the construction and operation of Federal-aid highways.

Highway builders and users have responded remarkably well to these new and evolving standards. Despite a tripling of vehicle miles traveled, emissions from motor vehicles have dropped significantly since 1970. Wetlands affected by highways now are mitigated at an average ratio of more than 2 acres for every 1 acre of impact. Endangered species routinely are avoided on highway projects. The Nation's roadways are gentler on the environment than ever before.

Yet the adaptation of highway construction and operation to the environment is much more than a response to an increasingly complex network of laws. These practices are not driven by *mandates* but by *values*. They reflect a philosophy that building highways compatible with the environment makes good sense. It makes sense to "keep it simple" by raising the lights on an Indiana highway so endangered bats do not fly into traffic. It makes sense to "green" a Pennsylvania highway by using scrap tires to fill embankments on bridges. It is "ecological" to plant native buffalo grass and prairie plants along roadsides in Kansas. It is civic, as well as civil, engineering to revitalize businesses and public facilities in an economically depressed area while building an interstate in Alabama. The Nation's roads are built to be sensitive to their context because the transportation community and the public value the scenic, aesthetic, historic, environmental, and community resources that surround them.

Over time, those who travel our highways have come to appreciate them not just as a means to a destination, but as unique resources themselves. Whether it is the Going-to-the-Sun Road, the Natchez Trace Parkway, or Historic Route 66, these roads capture the beauty and history that is America. There is no law that requires that—just the dedication and vision of those who build projects on the Federal-aid highway system.

April Marchese
Director of Human and Natural Environment
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Director of Project Development & Environmental Review
Federal Highway Administration

Get In, Stay In, Get Out, Stay Out

An ABC solution—prefabrication—offers a faster, cheaper way to build new bridges for addressing the deterioration of some U.S. spans.

(Above) The road deck for France's Millau Viaduct was built by launching its orthotropic steel superstructure from both ends of the bridge to meet over the Tarn River. The viaduct features about 1.61 kilometers (1 mile) of orthotropic steel superstructure. *Photo: Groupe EIFFAGE.*

by Vasant Mistry and Al Mangus

Nearly half—more than 250,000—of U.S. bridges according to the National Bridge Inventory are in the 25- to 50-year age range. This is a major concern for many State departments of transportation (DOTs) and the Federal Highway Administration (FHWA) because many bridges have a life expectancy of 50 years—making them near the ends of their anticipated life cycles. The current goal with new bridge construction is a 100-year lifespan.

In addition to aging, about 26 percent of the bridges in the United States are deficient. Highway capacity also has increased little during the past two decades. But traffic demand has grown tremendously, causing increased congestion, with bridge construction projects compounding the problem. Traffic control represents anywhere from 20 to 40 percent of construction costs, and user delays are priced at thousands of dollars per day in heavy traffic areas.

Accelerated bridge construction (ABC) is a swift and economical solution for rehabilitating or rebuilding bridges to address aging, substandard load capacity, safety, and congestion. The following success stories show that many State DOTs, related agencies, and contractors have used ABC, especially prefabrication, effectively.

A Look at ABC

ABC can be defined as replacement or new bridge construction that uses design and construction methods to minimize impacts to the traveling public, river traffic, railroads, and the environment—all while maintaining high levels of quality and safety. Examples include "midnight" lane or road closures, contracting incentives/disincentives, prefabricated elements, and high-performance materials to reduce the typical duration of onsite construction, improving safety and minimizing traffic disruption while producing a higher quality bridge. ABC can be used anywhere along the entire process, starting with planning, where early right-of-way acquisition, expedited environmental permitting, and innovating contracting can speed the early stages. During actual construction, prefabricated elements and cutting-edge equipment and innovations, such as self-propelled modular transporters (SPMTs) and concurrent onsite engineering operations, can hasten the later stages.

One particular ABC method involves maximizing prefabrication—building bridge elements and systems that range from small, discreet parts to entire spans offsite and then moving them into place swiftly—which can greatly cut the time invested in construction, minimizing traffic congestion and safety hazards. Prefabricated deck panels for bridges, for example, can speed construction considerably, with minimal disruption to the traveling public.

"Prefabrication also allows a controlled construction environment that permits safer access by the worker, improves quality, and extends the life and performance of materials," says Byron Lord, program coordinator for Highways for LIFE at FHWA. "Frequently it significantly reduces the man hours of labor required to produce the bridge."

"The need for prefabrication continues to increase due to the growing reconstruction necessary as we celebrate the 50th anniversary of our aging interstate highway system this year," says Mary Lou Ralls, principal at Ralls Newman, LCC, an Austin, TX, consulting firm, and former State bridge engineer and director of the bridge division at the Texas Department of Transportation (TxDOT). "Prefabrication is particularly attractive in addressing this need," she adds, "because of the combined benefits of accelerated construction, so critical in our congested environments, and the improved quality possible with fabrication in a more controlled environment. This improved quality will help these bridges achieve the 75 to 100 years of service that are now needed."

By maximizing prefabrication and minimizing onsite construction time, State DOTs and other bridge owners can reduce costs in time and materials, decrease congestion, and increase safety.

Maximizing Prefab Technology

Nearly all parts of bridges can be prefabricated, theoretically, but what *is* built ahead of time depends on the particular project. All or part of the construction can consist of prefabricated or precast elements. According to Lord, prefabrication is applicable to most bridge projects, but managers must weigh the cost of materials and the cost of congestion and inconvenience to stakeholders. "As in every engineering decision, it is important to take into consideration the relevant factors that determine the best application for the conditions and needs," he says. (For more information, see the FHWA report *Framework for Prefabricated Bridge Elements and Systems (PBES) Decision-Making*, available online at www.fhwa.dot.gov/BRIDGE/prefab/if06030.pdf.)

Using precast elements for building larger bridges can be cost effective in materials and alleviating congestion, because precasting concrete "thrives on replication," says Hratch Pakhchanian, a structural design engineer with FHWA's Eastern Federal Lands Highway Division.

Bridge elements might include deck panels, sometimes using fiber-reinforced polymer (FRP) technology. The panels can be moved and placed one right after the other during construction, and later, during repair. With the more traditional approach, an old deck would be removed and a new framework of reinforcement put in place, with the concrete being cast onsite. The waiting time for curing is normally 4 weeks. However, with the use of precast elements that same deck

Why Are the Nation's Bridges In Such Poor Shape?

One of the major reasons for the present state of U.S. bridges tracks back to age: The combination of weather and vehicle traffic leads to deterioration, including corrosion, fatigue, absorption of water, and loss of prestress. In addition, impact, overload, scour, fractures, seismic activity, foundation settlement, cracking, and bearing failure often damage bridges. Much more so than buildings and other structures, bridges are subject to live loads that come and go. These include cars, trucks, and people, but also wind, accumulated snow, and even earthquakes.

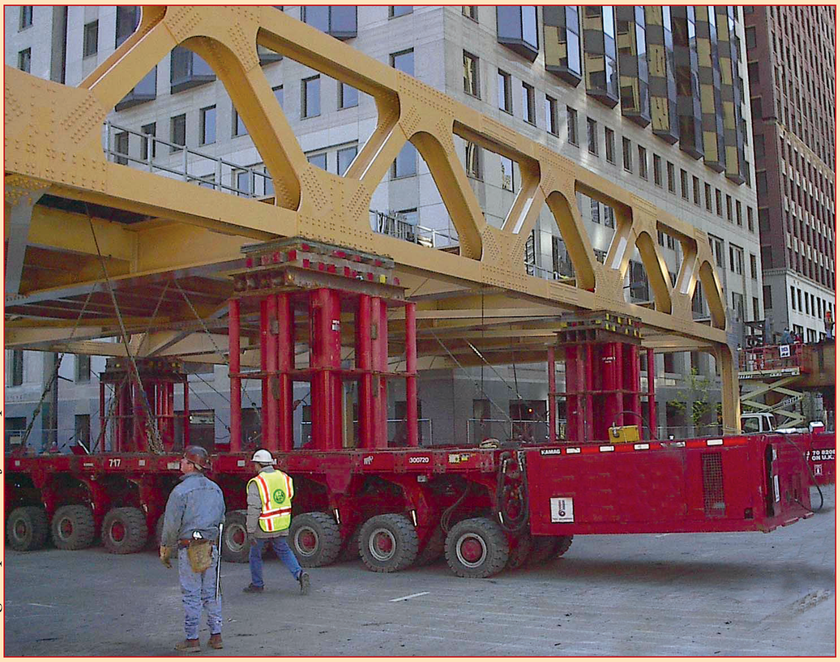
Heavy traffic especially causes much cyclic loading and deterioration. Fast-moving traffic stresses a bridge horizontally, and the "vehicle bounce" across the bridge, increases the vertical loading. And the heavier the load, the more damage is caused.

Studies suggest that bridges deteriorate slowly during the first few decades of their 50-year design lives, followed by rapid decline in the last decade. "If these predictions are correct, the Nation is facing enormous rehabilitation and reconstruction costs over the next two decades," according to the Web site *www.nationalbridgeinventory.com*. "Compounding this issue is the dramatic increase in both the weight and number of heavy commercial vehicles, which impose an exponential increase in damage to the infrastructure."

Crawling With Bridges

FHWA officials report that self-propelled modular transporter (SPMT) equipment is being used more and more in the United States, owing partly to the recommendations of a U.S. team that studied ABC in Belgium, France, Germany, Japan, and the Netherlands in April 2004.

SPMTs are multiaxle, computer-controlled vehicles that can move in any horizontal direction while maintaining their payload geometry and equal axle loads. Typically, four-axle or six-axle units can be coupled side-by-side and end-to-end to suit the weight or dimensions of the cargo. Hydraulic drive motors are mounted on selected axles and can provide forward and reverse travel. Speed depends on load, number of axles, inclination of route, and the number of diesel-driven power packs. Top speeds typically range from 10 to 12 kilometers (6.2 to 7.5 miles) per hour.



Chicago Department of Transportation

As part of the Wells Street Bridge project in Chicago, IL, SPMTs moved a 34-meter (111-foot)-long, 7.6-meter (25-foot)-high, 386-metric-ton (425-ton) truss span into place, where it was installed over 1 weekend.

Each SPMT unit can be steered individually and is monitored and controlled by a computerized system. Each suspension can rotate 360 degrees to provide nine different steering programs, such as forward, reverse, left or right, diagonal, transverse, and circular. Two electronic steering controls can be used for two or more separate SPMT groups and connected to act as one integral unit. The capacity of each axle line varies depending on the model but generally ranges from 32 to 40 metric tons (35 to 44 tons).

may take only a few days or hours for placement, and be ready for vehicle use immediately.

Likewise, bridge elements such as columns, parapets, box beams, and bent caps can be made from prefabricated materials. Under precasting, the concrete is often prestressed during the offsite curing and bridge parts are threaded together with high-performance steel, which provide added durability.

Entire superstructures including the deck and its railing, striping and signage, the beams or girders supporting the deck, and, in the case of steel bridges, truss spans can be built offsite—sometimes hundreds of miles away—and be moved to a different site for assembly.

FHWA recently held a series of regional workshops on ABC. Applied technology transfer workshops also were held, with agreements between FHWA and the bridge owners to facilitate using ABC techniques for specific bridges. Some examples of ABC successes can demonstrate the advantages of prefabricated elements and systems.

Virginia: Dead Run and Turkey Run Bridges

In northern Virginia, FHWA's Federal Lands Bridge Office refurbished the Dead Run and Turkey Run Bridges on the George Washington Memorial Parkway in 1998 using prefabricated deck panels. Because of the parkway's heavy commuter use—average daily traffic of 43,000 vehicles in 1996—the bridges needed to be kept open to traffic on weekdays during replacement of the decks.

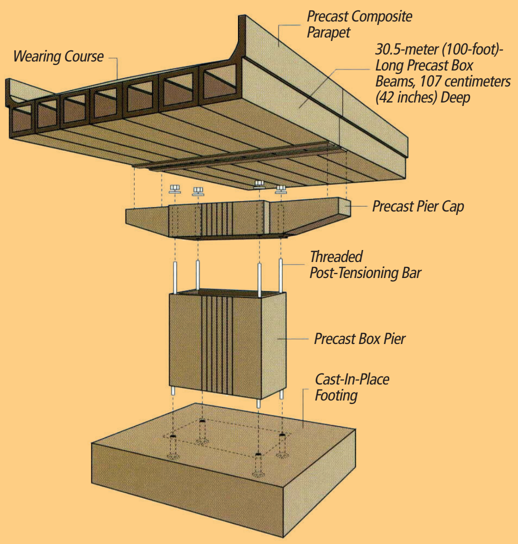
The three-span Dead Run Bridge consists of two structures, each carrying two lanes of traffic. The Turkey Run Bridge is also two structures of two lanes each, but it has four spans. Both bridges have a 20.3-centimeter (8-inch) concrete deck supported on steel beams with noncomposite action (deck and girders are not structurally linked, and they function independently of one another). This aspect of the original design, along with the use of precast concrete deck panels, facilitated quick deck replacement and allowed the structures to be kept open during weekday traffic. (See also the September/October 2002 issue of PUBLIC ROADS.)

The construction rate was replacement of one span for one bridge per weekend. The construction sequence involved closing each bridge on a Friday evening, saw cutting the existing deck into transverse sections that included curb and rail, removing those sections of the deck, setting new precast panels, grouting the area beneath the panel and above the steel beam, and reopening the bridge to traffic by Monday morning.

West Virginia: Howell's Mill Bridge

Another deck replacement project involved replacement of an entire superstructure using FRP. In a scenario similar to the Virginia project, when the West Virginia Department of Transportation (WVDOT) overhauled the Howell's Mill Bridge in Cabell County in 2003, significant daily traffic needed to be accommodated.

The West Virginia project also had constructability (difficulty posed to builders by a project's surroundings or circumstances) issues. For example, work on a neighborhood bridge could be complicated by heavy



This diagram of a portion of the Baldorioty de Castro Avenue overpasses in San Juan, PR, shows some of the elements of a concrete bridge that can be built offsite, transported to the construction site, and then put in place. *Source: Precast/Prestressed Concrete Institute.*

traffic on an interstate that runs underneath the highway. Work on other bridges might encounter different constructability issues such as difficult elevations, long stretches over water, or crowding by adjacent buildings.

For the Howell's Mill bridge project, the requirement to accommodate traffic became a constructability issue, and that issue was largely overcome through use of a prefabricated, full-depth, FRP deck to speed construction.

The 75-meter (245-foot)-long, 9.9-meter (32.5-foot)-wide bridge required a replacement deck of 728 square meters (7,833 square feet). The deck arrived onsite in 2.4- by 9.9-meter (8- by 32.5-foot) panels with a factory-applied skid-resistant surface. All panels were attached in just 3 working days. At about 2.27 metric tons (2.5 tons) each, the panels weighed 20-percent less than their concrete counterparts and required no forms to set up or strip off. And the panels are immune to chloride ion-induced corrosion, making them ideal for environments where deicing chemicals are commonly used.

As an added benefit, panel construction in a controlled environment meant that quality control and sampling of materials was accomplished at the factory, saving time and money.

Texas: Several Successes

In downtown Houston, TxDOT needed to replace two 113-span sections of the IH 45 Bridge in 1997 and used precast bent caps on the existing columns to speed construction and avoid congestion. Designers estimated that a conventional bridge system would require more than a year and a half of construction, with user delay costs of $100,000 daily. Instead, by using precast bent caps, the 226 spans were replaced in 190 days.

The prefabricated elements enabled much of the work to be repetitive, which had its own benefits, according to Kenneth Ozuna, transportation engineer supervisor for TxDOT. "This job was a success due to the repetition of the work and the contract language establishing a schedule coupled with incentives and disincentives," he says. "The work involved repetitive work on more than 60 of the 113 spans—resulting in high efficiency of work crews. An added benefit was convenient access—an entire lane beneath and parallel to the bridge provided unrestricted access for cranes, deliveries, and staging of operations."

Using precast columns on cast-in-place footings or drilled shafts also can greatly reduce bridge construction times. Columns can be segmental and hollow or concrete-filled. In Texas, the Dallas/Fort Worth International Airport decided to upgrade its Skylink people mover system to accommodate new terminals and more passengers. Casting conventional concrete columns with forms and guy wires for the reinforcing would have been difficult and expensive because of interference with the airport apron. Aircraft terminals and gates would have had to be closed.

WVDOT

Two construction workers secure one of the FRP deck panels on West Virginia's Howell's Mill Bridge. All the prefabricated panels were placed in just 3 days.

TxDOT

To speed refurbishment of the IH 45 bridge in Houston, TxDOT decided to use precast bent caps set across the existing columns to support the new roadway, which also made use of precast, prestressed deck panels and I-beams.

Instead, airport officials opted for a precast segmental system of columns. The shorter work time enabled column construction to occur at night, with minimal disruption to taxiing airplanes and baggage movers.

Another Texas project makes use of both prefabricated substructures and superstructures. In the early 1990s, Texas State Highway 249 was upgraded from a four-lane, at-grade road to a limited-access freeway. Two overpasses were built at Louetta Road to carry three lanes in each direction, plus shoulders and ramp transitions. The superstructure consists of trapezoidal, 137-centimeter (54-inch) U-beams as well as precast deck panels supported on the U-beams' top flanges with a cast-in-place composite concrete topping. At the substructure level, at the interior bent, a single segmental pier supports each beam. All beams and piers were precast, designed, and built using high-performance, high-strength concrete.

Developments continue in the use of bent caps and other prefabricated substructures, Ralls notes. For instance, there is a current National Cooperative Highway Research Program project to develop connection details for precast bent cap systems in seismic regions. And FHWA is sponsoring a Multidisciplinary Center for Earthquake Engineering Research project to develop details for segmental columns in seismic regions, she says.

Louisiana: Lake Pontchartrain Bridge

Bridge designers and builders are finding ways to prefabricate entire segments of a superstructure. Units may include steel or concrete girders prefabricated with a composite deck, pieced together near the worksite, and then lifted into place. This scale offers tremendous potential advantages for traffic flow and constructability.

The Big Pick

The Church Street South Extension project over the New Haven Interlocking and Rail Yard was part of a broader transportation endeavor involving I–95 and New Haven Harbor. To minimize disruption to train service and eliminate hazards in building a bridge over active rail lines, the Connecticut Department of Transportation (ConnDOT) specified that the biggest segment of the 390-meter (1,280-foot) bridge be completed in a single weekend night.

The contractor built the 98-meter (320-foot), 771-metric-ton (850-ton) span in a few months. Only one crane in the world was capable of moving the truss—Lampson International LLC's Transi-Lift® LTL-2600.

One of the stakeholders in the project, a railroad company, required that a crane capacity of 150 percent of the truss weight be used to accommodate the weight of attendant items and as a safety margin. The largest mobile, land-based, high-capacity crane in existence, the LTL-2600's maximum capacity is 2,359 metric tons (2,600 tons). Even so, it barely fit the bill: The operation demanded a crane capacity of 1,406 metric tons (1,550 tons) at the pick (lift) radius of 57 meters (186 feet). With remain-in-place forms, rigging, and other items, the truss weighed 951 metric tons (1,048 tons) when it was actually moved.

ConnDOT

The "Big Pick" employed the world's largest mobile crane, which took 4 weeks to assemble onsite and has a lift capacity greater than 2,359 metric tons (2,600 tons).

The design firm developed detailed crane erection plans. The crane's parts were trucked to New Haven on more than 200 tractor trailers. It took 1 month for the crane to be put back together. But before the crane could even enter the picture, the project team had to build a pad to support it.

Poor soil conditions required that the crane be supported by a foundation consisting of a 0.9-meter (3-foot)-thick reinforced concrete mat supported on 0.6 meter (2 feet) of compacted stone base. Plans for the pad specified 1.8 meters (6 feet) of excavation depth, 71 centimeters (28 inches) of stone, 20 centimeters (8 inches) of gravel, and 0.9 meters (3 feet) of 2,268 kilograms (5,000 pounds) per square inch concrete.

The sequence of events during the 3 hours allotted for the "Big Pick," as it came to be called, was well rehearsed. Advance preparations for the night of the actual lift included rigorous tests for the crane pad, rigging, and lift sequence. Team members ensured their tasks would move like clockwork—secure the work areas for the lift, illuminate the site, check the truss rigging, clear all trains from the area, deenergize the electrified catenary system and power feeder wires, get the "all-clear" for wires and trains, and check weather and wind speed to determine if the lift was a "go."

Finally, with about 500 spectators viewing the event in the early morning hours of May 3, the crane lifted the entire truss 19.8 meters (65 feet) into the air and moved it 30.5 meters (100 feet) toward the railroad tracks, where it was set into position. "It went off without a hitch; it was flawless," observes Paul Breen, assistant district engineer for ConnDOT's District 3.

By the time the ribbon was cut and the bridge opened to traffic in December 2003, the project had been completed 5 months ahead of schedule and $0.5 million under its $32 million budget.

ConnDOT

A marvel of the ABC approach, a 771-metric ton (850-ton) steel truss span was set in place over rail lines in New Haven, CT, in one operation at midnight to avoid impacts on a vital railroad corridor.

In Louisiana in 2002, the Department of Transportation and Development (DOTD) sought to replace an I–10 bridge span over Lake Pontchartrain. The original span, built using prefabrication, was 19.8 meters (65 feet) long and 14 meters (46 feet) wide and weighed 317 metric tons (350 tons). The new span, with a 19-centimeter (7.5-inch) concrete slab cast on precast prestressed concrete girders, was built on a barge on the north shore of the lake and then floated to the bridge site.

The contract allowed the construction company 24 hours of roadway closure for span removal and replacement under an incentive/disincentive clause. The firm placed the bridge span in much less time than that, enabling it to earn the maximum incentive. For DOTD this approach meant minimal disruption to the main artery into New Orleans and the gulf coast and minimized the use of a 161-kilometer (100-mile) detour route.

Wisconsin: Mississippi River Bridge

In Wisconsin, a new bridge across the Mississippi River has a totally prefabricated superstructure. In 2002, the Wisconsin Department of Transportation (WisDOT) decided to build the 784-meter (2,573-foot)-long, 15-meter (50-foot)-wide bridge, changing U.S. 14/61/WIS 16 from a two-lane to a four-lane route to provide safer, more efficient access to downtown La Crosse and into Minnesota. WisDOT opted to use a central prefabricated tied arch section and float it into place before connecting it to the permanent bridge piers.

The bridge elements were built 145 kilometers (90 miles) from the site in pieces manageable for shipping and erection. They were then assembled on barges near the bridge site. The 145-meter (475-foot)-long, 26.5-meter (87-foot)-high centerspan steel arch superstructure was finally floated into place in December 2003.

The prefabrication enabled WisDOT to keep the main channel of the Mississippi open to all river traffic during construction per United States Coast Guard requirements. Contract specifications did not allow temporary structures in the river during navigation season. Erecting the arch on barges allowed the work to proceed without interfering with river navigation. It also enabled the contractor to work on both the river piers and the arch simultaneously, speeding the construction schedule.

Connecticut: Church Street Span

Because prefabrication moves so much of the preparation work for bridge construction offsite, the amount of time that personnel are required to work onsite, frequently in or near traffic, at elevation, over water, or near power lines is greatly diminished, thus contributing to improvements in work zone safety.

In Connecticut in 2003, part of the Church Street South Extension project required replacing a 98-meter (320-foot) steel truss span across a rail yard with active power lines, creating a constructability issue. To address the issue, the largest mobile crane in the world lifted a 771-metric-ton (850-ton), prefabricated replacement span into place in a single night, reducing the time that personnel otherwise would have had to work around power lines and moving trains.

North Carolina: Linn Cove Viaduct

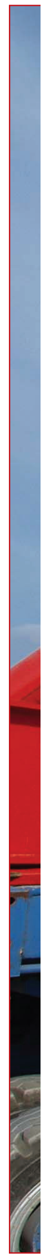
Using prefabricated substructure elements reduces the heavy equipment required and the time that the equipment is onsite. The result is less potential damage to sensitive environments compared with conventional construction.

Adjacent to North Carolina's Grandfather Mountain, the Linn Cove area is one of the State's most sensitive biological areas. In an early prefabrication success, engineers in 1983 completed a bridge at Linn Cove as part of the Blue Ridge Parkway, using prefabricated elements and an innovative construction method that had little impact on the area.

To avoid placement of heavy equipment in Linn Cove, the bridge was built in one direction from the south abutment to the north almost entirely from the top down. The only exceptions to this approach were construction of the initial span on temporary piers and construction of a temporary timber bridge that enabled the micropile foundation drilling machine to prepare several of the foundation sites ahead of the erection of the superstructure. "Use of prefabricated elements allowed the construction to be done with little falsework (temporary elements), which minimized disturbance to the ground underneath the bridge," says Gary Jakovich, a senior bridge engineer with FHWA.

EFLHD

Building the Linn Cove Viaduct from the top down obviated a significant footprint on ecologically rich Grandfather Mountain in North Carolina.



The design included 153 superstructure segments, each weighing 45.4 metric tons (50 tons), along with 40 substructure segments weighing up to 40.8 metric tons (45 tons) each. Today the 379-meter (1,243-foot) long Linn Cove Viaduct winds around Grandfather Mountain in an S-shape at an elevation of 1,250 meters (4,100 feet).

Millau Viaduct

At 2.5 kilometers (1.5 miles) long, with some of its slip-formed reinforced concrete columns taller than the Eiffel Tower and an orthotropic steel deck superstructure 270 meters (885 feet) above the river it crosses, the Millau Viaduct in southern France is the tallest vehicular bridge in the world. It was completed in December 2004 for half its original price estimate. State-of-the-art launching techniques, meaning the prefabricated pieces were assembled and launched out from the bridge's abutments, eliminated most of the risk of working on a high bridge.

The four-lane bridge carries the new A75 toll road over the Tarn River valley, which splits the Massif Central and links the towns of Clermont-Ferrand and Béziers. A driver paying the A75 tolls saves 3 hours when driving from Paris to Montpellier or to the freeway systems in France and Spain.

Seven site-cast, slip-form-reinforced concrete piers support the viaduct. They range in height from 78 meters (256 feet) to 245 meters (804 feet), depending on their placement along the uneven valley floor. A nearly 100-meter (328-foot) pylon caps each pier, making the tallest column 343 meters (1,125 feet), which is just 100 meters (328 feet) shorter than New York City's Empire State Building.

A total of seven cable-stay towers support eight orthotropic steel superstructure spans resting on the seven slip-formed concrete columns. The Millau Viaduct is the world's largest orthotropic steel superstructure, consisting of a 204-meter (669-foot) span at either end of the bridge and six 342-meter (1,122-foot) spans in between. One hundred and fifty-four stays attached to caret- or wedge-shaped steel pylons attached to the tops of the concrete piers support the orthotropic steel spans.

For all its impressive dimensions, the Millau Viaduct appears to onlookers as delicate and transparent. The viaduct uses the least material possible, and the most practicable for each component, also making it less costly. To accommodate expansion and contraction of the deck, each concrete column splits into two thinner columns below the roadway, forming a V-shaped frame.

"The bridge not only has a dramatic silhouette, but crucially it makes the minimum intervention in the landscape," indicates its architectural design firm, Foster and Partners.

The bridge curves slightly on a 20-kilometer (12.4-mile) radius, and the roadway has a slope of 3 degrees. Both features provide improved visibility for drivers and make the bridge less monotonous to drive, increasing both alertness and safety.

Prefabrication and a new type of high-grade steel were instrumental in reducing the total weight of the orthotropic steel superstructure. Thousands of pieces were crafted in Eiffage's (company descended from the Eiffel Tower's creator) steel-fabrication facilities in the towns of Lauterbourg and Fos sur Mer and trucked to both ends of the bridge site. These shop-fabricated deck units of 60 metric tons (66.1 tons), each 4 meters (13.1 feet) by 17 meters (55.8 feet), were field-welded in assembly-line processes at both sides of the valley and launched toward each other, meeting over the Tarn River.

Because of the great distances between piers, temporary steel falsework towers were built between them to take the weight of the deck sections as they were pushed out from the bridge ends. Using a system of American-made, high-capacity hydraulic jacks, drawing on high-pressure cylinders and pumps, and guided by global positioning system (GPS) technology, the deck sections were slid out at a rate of 60 centimeters (2 feet) every 4 minutes. Although American technology launched this amazing structure, it is rarely used in the United States. (For an example in Iowa, however, see "Iowa Issues Video on Innovative Bridge Construction Technology" in the March/April 2005 issue of PUBLIC ROADS.)

When the sections were all in place, the whole deck weighed 36,000 metric tons (39,683 tons), far less than a conventional concrete deck. Another figure: U.S. $523 million (300 million euros), the total cost of the bridge—half the original estimate.

Get In, Stay In, Get Out, Stay Out

A mantra frequently used by the highway community—"Get In, Stay In, Get Out, Stay Out"—has become popular because of the need to reduce traffic congestion caused by work zones. The slogan also is relevant to the reconstruction of bridges because of the pivotal roles that they serve in most transportation systems and the resulting need to avoid long construction times.

The remaining five steel caret- or wedge-shaped pylons that support the orthotropic steel Millau Viaduct with cable stays were prefabricated and then moved into place using high-tech self-propelled modular transporters (SPMTs) like the one shown here. *Photo: Groupe EIFFAGE.*

The various projects featured in this article prove the effectiveness of ABC for rehabilitating and building bridges to minimize impacts on stakeholders. Many of the projects contain more than one ABC element, such as contracting mechanisms, use of midnight road or bridge closures, and innovative construction methods and tools.

ABC has helped reduce costs, production times, and other frustrations to stakeholders associated with bridge construction.

Vasant Mistry is the senior bridge engineer at FHWA. He serves as the national technical expert for steel bridges and is responsible for promoting high-performance steel, ABC technology, cost-effective steel bridge design, and the use of innovative bridge technologies and materials. He has been with FHWA for 26 years.

Alfred R. Mangus is a transportation engineer with the Office of Structures Contract Management at the California Department of Transportation (Caltrans). He has 29 years of experience, including 14 years with Caltrans. He has received two professional awards from the James F. Lincoln Arc Welding Foundation.

For more information, contact Al Mangus at 916-227-8926, 916-961-ASCE, or al_mangus@dot.ca.gov. Prefabricated bridge elements and systems are one of FHWA's priority, market-ready technologies and innovations. More information is available at the R&T Web site www.fhwa.dot.gov/crt.

A Noteworthy Year

The Golden Anniversary of the Eisenhower Interstate System was just one of several significant anniversaries in highway history in 2006.

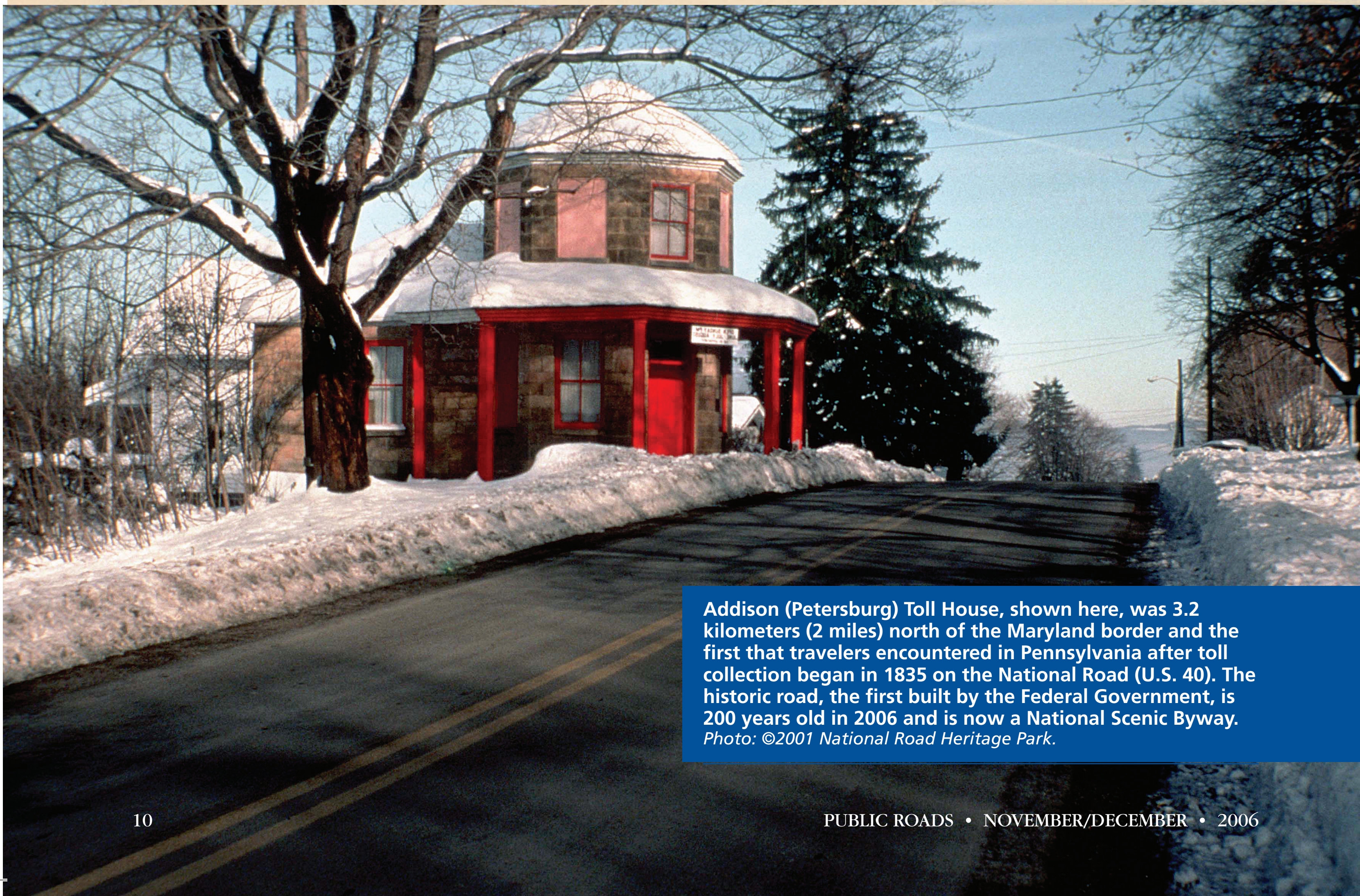
by Richard F. Weingroff

In 2006, the Federal Highway Administration (FHWA) and its partners celebrated the 50th anniversary of the Dwight D. Eisenhower National System of Interstate and Defense Highways. However, 2006 also marked significant anniversaries of several other special events in highway history, including the 200th birthday of the National Road, the 90th anniversary of the Federal-Aid Road Act, and the 80th anniversary of historic Route 66. Over the past 3 years, a number of PUBLIC ROADS articles have chronicled the story of the Interstate System, but these other historic stories deserve to be told as well.

This year of anniversaries is an opportunity to take a look at some of the most significant events in the history of highways in the United States.

The National Road—1806

On March 29, 1806, President Thomas Jefferson signed legislation authorizing him to appoint three commissioners to build a road from the Potomac River at Cumberland,



Addison (Petersburg) Toll House, shown here, was 3.2 kilometers (2 miles) north of the Maryland border and the first that travelers encountered in Pennsylvania after toll collection began in 1835 on the National Road (U.S. 40). The historic road, the first built by the Federal Government, is 200 years old in 2006 and is now a National Scenic Byway. *Photo: ©2001 National Road Heritage Park.*

Carl Rakeman, an artist with the U.S. Bureau of Public Roads (BPR), depicted the National Road at Willis Creek just west of Cumberland, MD, showing the Conestoga wagons and stagecoaches that were common on the road in its heyday.

MD, to the Ohio River at Wheeling, WV (then in Virginia). With rivers being the fastest means of travel among the States, the first National Road would provide a land bridge connecting the Potomac and Ohio Rivers for settlers bound for the public lands on sale in the new State of Ohio. The road also would facilitate trade and bind the States in what Jefferson called a "union of sentiment."

Congress had to think innovatively to get the road underway. Instead of using tax revenue, the 1806 law applied 2 percent of the revenue from the sale of Ohio's public land to building the road. To address the belief that the Government did not have the constitutional authority to build a road on land owned by the States, President Jefferson was required to secure consent from the three States through which the National Road would pass. Maryland and Virginia quickly consented, but Pennsylvania delayed until its representatives won a commitment that the road would be built through its towns of Uniontown and Washington, thus ending the Nation's first interstate highway routing dispute.

President Jefferson's three commissioners took 4 years to select the route. Beginning in May 1811, contractors cleared a roadway 20 meters (66 feet) wide with a 9-meter (30-foot)-wide stone surface. The first section opened in 1813 and immediately saw heavy traffic as contractors worked to extend the 209-kilometer (130-mile) road to Wheeling, which the road reached in 1818.

Under pressure from Ohio and newly admitted Indiana (1816) and Illinois (1818), Congress passed legislation in 1820 authorizing funds to lay out a road from Wheeling to the eastern bank of the Mississippi River. Funds for construction, first authorized in 1825, again came from 2 percent of the public land sales in the new States.

The U.S. Army Corps of Engineers built the extension, which was laid out as straight as possible, 24 meters (80 feet) wide, from Wheeling to Vandalia, then the capital of Illinois. In eastern Ohio, the availability of stone for road building allowed for high construction standards, but the rest of the extension was little more than a cleared and graded dirt track. Vandalia remained the terminus because an 18-year struggle between Alton, IL, and St. Louis, MO, to be the primary Mississippi River port was still unresolved when Congress stopped funding the National Road in 1841.

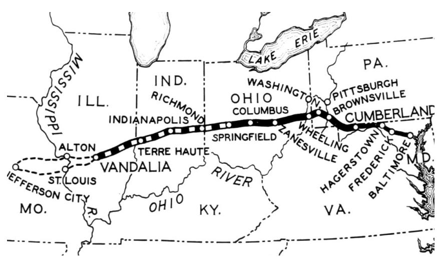
As the roadway expanded westward, the original section deteriorated under heavy use. Still trying to save tax revenue, Congress approved a bill in 1822 calling for toll collection to pay for maintenance. President James Monroe vetoed the bill because Federal toll collection within the States implied a sovereign authority that he did not believe the Constitution granted. Rather than pay for maintenance with tax revenue, Congress decided to turn the road over to the States to operate as a turnpike. Maryland, Ohio, Pennsylvania, and Virginia agreed to accept ownership, but only after the Government paid for reconstruction.

Other 2006 "Zero" Anniversaries

- 1766: First "Flying Machine" stage wagon run between Philadelphia and New York
- 1806: Lewis and Clark's Corps of Discovery returns from Pacific Northwest to St. Louis
- 1846: First plank road in the United States (New York State)
- 1926: Cooperative agreement by National Park Service and Bureau of Public Roads for construction of roads in national parks and monuments
- 1936: Opening of San Francisco-Oakland Bay Bridge
- 1966: The Department of Transportation Act of 1966 authorizes creation of the Department of Transportation
- 1966: National Historic Preservation Act of 1966
- 1966: National Traffic and Motor Vehicle Safety Act of 1966

The National Pike, 1840

The Federal Government built the National Road (National Pike) from Cumberland, MD, to Vandalia, IL, and gave it to the States in the 1830s to operate as a turnpike. As shown on this map, Maryland built an extension from Cumberland to the port of Baltimore. *Source: FHWA.*



As late as the 1930s, U.S. 40 included this National Road "S" bridge west of Hendrysburg, OH. The bridge was replaced with an arch bridge during reconstruction of the highway in 1933.

Traffic on the National Road declined in the 19th century after railroads took much of its interstate business. This photograph shows a railroad line (left of picture) along the National Road west of Cumberland, MD.

By the time the handoff was completed with the transfer of the Illinois segment in 1856, the age of the railroad was well underway, taking traffic from the National Pike. As revenues declined, so did the roadway.

In an 1894 history, Thomas B. Searight described the National Road as a highway "grand and imposing, an artery … largely instrumental in promoting the early growth and development of our country's wonderful resources, … influential in strengthening the bonds of the American Union, and at the same time … replete with important events and interesting incidents." In that spirit, the U.S. Department of Transportation designated the Historic National Road (the National Pike) a National Scenic Byway from Maryland to Illinois.

Federal-Aid Road Act of 1916

During the second half of the 19th century in the railroad era, the Nation's roads, including the National Pike, deteriorated from lack of maintenance, resources, and interest. Interest, however, revived with the introduction of bicycles with large front wheels and small rear wheels in the mid-1870s and the "safety" bicycle (equal size wheels with pneumatic tires) in the 1880s. Bicycle groups such as the League of American Wheelmen joined with farm groups to demand better roads. The Federal Government responded with $10,000 for a road inquiry by the U.S. Department of Agriculture. On October 3, 1893, General Roy Stone, a Civil War hero, opened the U.S. Office of Road Inquiry (FHWA's first incarnation).

In the 20th century, the automobile replaced the bicycle as the motivating factor in the Good Roads Movement. By 1910, two competing ideas had developed. One was that the Federal Government should help the States improve farm-to-market roads to "get the farmer out of the mud." As an alternative, long-distance travel groups wanted the Federal Government to build national roads.

In 1916, Congress rejected Federal construction by approving a bill drafted by a committee of the American Association of State Highway Officials

This 1928 photograph shows an old National Road tavern along an unimproved section of U.S. 40 in Indiana, just east of the Ohio State line.

This section of the National Road (U.S. 40) in Wheeling, WV, was reconstructed in 1941 to provide a road width of 12 meters (40 feet).

(AASHO), as it was known at the time. The Federal-Aid Road Act of 1916, signed by President Woodrow Wilson on July 11, 1916, authorized Federal aid to the States on a 50-50 matching basis. To receive funds, a State had to have a highway agency capable of carrying out the requirements of the Act.

The United States entered World War I in 1917, taking workers and materials away from road building. When the war ended in 1918, work on Federal-aid highway projects quickly demonstrated the program's defects. The primary problem was that the States could use the funds on all existing or potential "rural post roads" outside cities. With virtually every road to choose from, the States spread Federal-aid funds among all their political subdivisions, with little focus on interstate roads, statewide links, or State line connections with adjacent States.

Long-distance road advocates renewed their efforts to promote national roads. For example, in 1919 the U.S. Army launched its first transcontinental convoy of military vehicles, a 2-month journey from Washington, DC, to San Francisco, CA. The convoy included Dr. S. M. Johnson, a good-roads advocate who spoke to crowds along the way in support of a bill that would establish a Federal highway commission to build national roads. A young officer named Dwight D. Eisenhower took part in the convoy and would cite the experience as one of the reasons why, as President, he supported construction of the Interstate System.

The Federal Highway Act of 1921, approved by President Warren G. Harding on November 9, resolved the issue—once and for all, as it turned out. The new law limited the expenditure of Federal-aid highway funds to 7 percent of the roads in each State. Within this limit, a maximum of three sevenths of each State's total mileage could be "interstate in character." Up to 60 percent of the funds had to be used on the "interstate" mileage.

The 1916 Act, as amended in 1921, launched the first "interstate system," as the "interstate in character" portion of the Federal-aid system was called. As work on the system increased, Federal and State highway officials considered the 1920s the "Golden Age of Road Building."

Historic Route 66

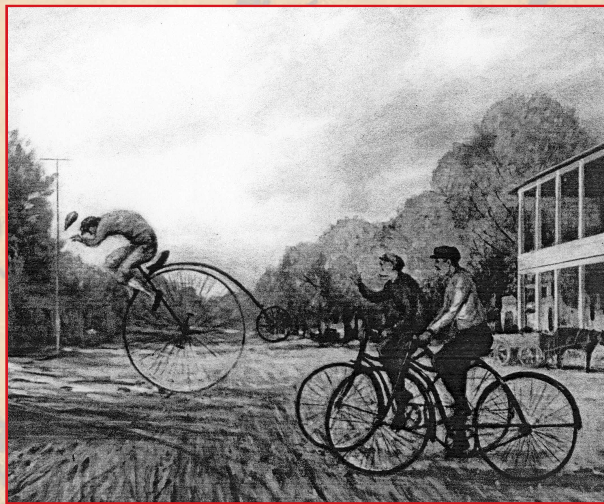
The 7-percent system, with its "interstate" subset, was a paper network that was not visible to the public. That would change in the mid-1920s.

During the 1910s and early 1920s, private associations selected routes for interstate roads, gave them names, and promoted their improvement by government agencies and use by travelers. Motorists, mapmakers, and road builders used the common names of Atlantic Highway, Dixie Highway, Jefferson Highway, Lee Highway, Lincoln Highway, National Old Trails Road, Pacific Highway, Yellowstone Trail, and 250 or so other named trails. However, as interstate traffic grew in the 1920s, the named trails proved to be a jumble of overlapping roadways, poor marking, and indirect routing through towns willing to pay dues to an association.

In 1925, Secretary of Agriculture Howard M. Gore, at AASHO's request, appointed a Joint Board on Interstate Highways to identify the main interstate roads, create a way of marking them, and adopt uniform signing for highways. Chief Thomas H. MacDonald of the U.S. Bureau of Public Roads (BPR) and two coworkers, E.W. James and A.B. Fletcher, represented BPR on the Joint Board, which included 21 State highway officials.

During meetings in April and August 1925, with regional meetings in between, the Joint Board identified the best interstate roads, decided to call them "U.S." highways, and applied numbers to them. The Board also developed uniform signs for the Nation's roads, including a marker for the U.S. routes based on the official U.S. shield (which can be seen on the back of a $1 bill). The new Agriculture Secretary, William Jardine, submitted the plan to AASHO, whose member highway agencies owned and operated the roads.

As AASHO considered the proposal, the named-trail associations lobbied for changes. The Joint Board had divided the interstate named trails among several numbers to put the associations out of business. Each association sought a single number for its route, while AASHO considered petitions from



Beginning in the 1880s, a bicycle craze swept the country, leading to demands for better rural roads. The "ordinary bicycle" (with the large front wheel) sparked the bicycle craze of the 1880s, but the "safety" bicycle (equal size wheels) expanded the craze. This painting by BPR artist Carl Rakeman illustrates one of the problems with the "ordinary," namely front spills known as "headers."

Cross-country motorists found rough conditions on "interstate" roads before the Federal and State highway agencies began cooperating on their improvement after the Federal Highway Act of 1921. In 1911, auto club "pathfinder" A.L. Westgard came across this crashed vehicle on a prairie road a few miles south of La Junta, CO.

BPR's Rakeman included this painting of a road in California—the first completed under the Federal-Aid Road Act of 1916—in his collection of paintings of historic highways.

cities that had been left off the network or that wanted a more prestigious number that would put the community on a mainline.

Of all the numbering disputes, none was more bitter than the fight over "60." The Joint Board assigned numbers ending in zero to the transcontinental or major east-west routes, with the lowest in the north. (With U.S. 10 through 90 accounted for, the Joint Board assigned U.S. 2, rather than U.S. 0, to the route closest to the Canadian border.) When the Joint Board's map was released, Kentucky Governor William J. Fields thought that his State had been "cheated." In sequence, U.S. 60 should have gone through Kentucky on the National Roosevelt Midland Trail, which was split among three less prestigious numbers (52, 62, and 150). The Governor's anger intensified when he spotted "60" on a route from Chicago to Los Angeles that passed through Illinois, Missouri, and Oklahoma—three of the States represented on the five-member Joint Board subcommittee that had assigned the numbers.

For months, the controversy raged. Compromises, such as designating the routes U.S. 60 North and U.S. 60 East or assigning U.S. 62 to the Chicago-to-Los Angeles route, failed. The solution came on April 30, 1926, when Cyrus Avery (Oklahoma) and B.H. Piepmeier (Missouri), who had been on the numbering subcommittee, met in Springfield, MO, on routine business. When they discussed the "60" controversy, Avery's chief highway engineer, John Page, noticed that the number "66" had not been used. Avery and Piepmeier sent a telegram to Chief MacDonald: "We prefer sixty-six to sixty-two." A compromise soon took shape. In July, AASHO assigned "60" to the route from Newport News, VA, through Kentucky to Springfield, MO, and "66" to the Chicago-to-Los Angeles route.

The controversy over "60" was the last major roadblock to approval of the U.S. numbered highway plan. On November 11, 1926, AASHO approved the plan and the uniform marking system.

As the named-trail associations faded, the U.S. route numbers became the core of the Nation's interstate system of paved two-lane roads. Some routes would take on an identity of their own, but none more so than U.S. 66.

Because it cut across most of the transcontinental routes and provided access to southern California, "Route 66" was heavily used. In addition, the reputation of Route 66 would be enhanced by unique circumstances. First, John Steinbeck chronicled the desperate flight of Depression-era farmworkers to California on Route 66 in his Pulitzer Prize-winning novel *The Grapes of Wrath* (1939), which director John Ford adapted in an Oscar-winning movie of the same name (1940).

Second, when songwriter Bobby Troup, just discharged from the Army, and his wife Cynthia headed for Los Angeles, they gave Route 66 a new image in 1946. After they turned onto Route 66 in St. Louis, Cynthia came up with the rhyme "Get your kicks on Route 66." Troup conceived a catchy melody for the narrative line ("It winds from Chicago to L.A./More than 2,000 miles all the way"), his wife's catchphrase, and a recitation of Route 66 cities ("don't forget Winona"). Nat "King" Cole's group, The King Cole Trio, recorded the song, which was a hit. Hundreds of road songs later, Troup's "Route 66" remains the most recognized.

Third, in 1960, the television series "Route 66" began its 4-year run before going into worldwide syndication. The popular series about two men sharing adventures as they traveled the country in a Corvette renewed the image of Route 66 as a symbol of the American road even as the highway with that number was passing into history.

The Interstate System launched in 1956 brought about the demise of Route 66. Some parts of two-lane Route 66 were incorporated into the new Interstates as half of a four-lane highway. Other parts, especially in

After AASHO approved the U.S. numbered highways in 1926, the new U.S. shields began to appear around the country. Rakeman illustrated the change by painting a sign crew shortly after they posted a U.S. 40 sign on the old National Road between Zanesville and Columbus, OH.

MaryAnn Naber, FHWA

This 1993 photo shows historic Route 66 west of Flagstaff, AZ, on the left and its replacement, I–40, on the right.

the small towns of the Southwest, were bypassed, including the final segment outside Williams, AZ, in 1984, and Troup's "highway that's the best" was no longer the interstate route for motorists. On June 26, 1985, the American Association of State Highway and Transportation Officials (AASHTO), which controls the numbering of U.S. routes today, eliminated Route 66 from the log of U.S. numbered highways.

The media reported AASHTO's action with images of Route 66 signs coming down, snippets from the movie "The Grapes of Wrath" and television's "Route 66," and snatches of Bobby Troup's song. The renewed interest prompted support groups to form in the Route 66 States to preserve the route and its lore. The State transportation departments, which had asked AASHTO to dedesignate the route, arranged "66" designations, such as "Historic Route 66" and "State Route 66," to preserve the link to the road's past.

Today, the highway that died in 1985 is one of the best known roads in the world. Tourists travel the old roadway, sometimes in rented Corvettes, in search of remnants of its famous past—a motel, a restaurant, a tourist attraction, and even abandoned bridges. Dozens of books and videos chronicle the old road. Congress has called for its preservation through the National Park Service's long-distance trails program, while the segments in Arizona, Illinois, and New Mexico have been designated National Scenic Byways. The 2006 Disney/Pixar animated film "Cars" depicts a fictional Route 66 town, Radiator Springs, as a once-vibrant town that had been left behind by traffic when it was bypassed by I–40. The town revives when the impatient hotshot main character discovers the values of life, love, and friendship in Radiator Springs.

Enthusiasts of Route 66 consider 2006 the 80th anniversary of the famous highway, but it was only one of the U.S. numbered highways AASHO designated on November 11, 1926. They formed the core of the "interstate system" that was essentially complete by the late 1930s when President Franklin D. Roosevelt, BPR's MacDonald, and his key associate, Herbert S. Fairbank, began thinking about the next-generation interstate highways that President Dwight D. Eisenhower would launch by signing the Federal-Aid Highway Act of 1956.

As these stories of the National Road, the Federal-Aid Road Act of 1916, and Route 66 reveal, the anniversary year 2006 offers a reminder that the Interstate System was the product of a long evolution of America's road network.

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MaryAnn Naber, FHWA

With the opening of I–40, many businesses on parallel Route 66 lost their customers, including these enterprises along Route 66 in Glenrio, NM, photographed in 1993.

A major principle guiding transportation planning in this Massachusetts city is safety for pedestrians and bicyclists.

Cambridge Plans A Livable Community

by Jeff Parenti

Improving the safety of the transportation network is an ongoing challenge, especially because many people still think of safety only in terms of vehicle occupants. However, of the 43,443 people killed by vehicles on U.S. roadways in 2005, 13.5 percent were nonoccupants, a group composed mainly of pedestrians and bicyclists.

Many urban areas increasingly feature sidewalks, bicycle lanes, and other amenities for nonmotorists as part of a sustainable transportation landscape. But to sustain safety, communities that are encouraging people to walk or bike on streets dominated by vehicles will need to make the safety of pedestrians and bicyclists a priority.

To foster pedestrian and bicyclist safety, one of these communities—the city of Cambridge, MA—uses a blend of multidisciplinary collaboration, aggressive policies, innovative engineering approaches, and a citywide policy that automobiles are not the only mode of travel.

"Our goal in Cambridge is to shift people from using cars to using other modes of transportation, like biking, walking and using public transit," says Henrietta Davis, a member of the Cambridge City Council who has sat on the Traffic, Parking, and Transportation Committee for 8 years. "We work on eliminating obstacles and creating incentives. For walking, for example, are the sidewalks safe and free of tripping hazards? Is snow and ice cleared so that on the snowiest days people don't decide to drive because sidewalks aren't clear and they don't feel safe walking?"

More broadly, any number of societal goals can help drive a push for safety. In Cambridge, the environment is a big concern. "Transportation planning should reflect our long-term vision of Cambridge as a livable, inclusive, and sustainable community," says Susanne Rasmussen, director of environmental and transportation planning for the Cambridge Community Development Department (CDD). "Cambridge has pledged to reduce its greenhouse gas emissions by 20 percent by 2010. Some of those reductions need to come from people driving less, and we have a responsibility to create a city that makes that both possible and desirable," she says.

(Above) A bicyclist and pedestrian pass each other crossing a road as a car approaches. Cambridge, MA, has made notable inroads in balancing the safety concerns of all three modes of transportation. *Photo: AAA Foundation for Traffic Safety.*

Embracing a Vision

A single project or program is unlikely to make a locality walkable or bikeable overnight. Nor will any individual action, no matter how well funded, reduce the number of trips motorists choose to drive alone. Fundamental changes in the transportation landscape require the cooperation of multiple stakeholders—elected officials, municipal staff, residents, and business owners—agreeing that walking and bicycling are important. Obtaining agreement is not easy because some believe that more cars bring more people and economic development.

Cambridge explicitly states its attitude toward nonmotorized traffic in writing in CDD's *Pedestrian Plan* in 2000. More than 100 pages in length, the plan explains that walking is important to Cambridge's vision and articulates the importance of nonmotorized alternatives: "A walkable city is especially important for people with disabilities, the elderly, children, and people who cannot afford to keep a car." A walkable community can help to create a thriving economic base, vital and distinctive retail centers, and strengthened and stabilized neighborhoods, according to the plan's authors. Walking also prevents pollution and promotes good health. Cambridge's embracing of pedestrians and bicyclists is especially important in a community with little room to accommodate the rising number of automobiles.

A look at modal split is one means of measuring an area's attitude toward multimodalism. According to journey-to-work data from the 2000 census, a minority of Cambridge residents traveled to work by driving alone; in fact, barely one-third did, less than half the figure for the rest of Massachusetts. Nearly 30 percent of Cambridge residents walk or bike to work. This modal split, with so little reliance on the automobile, is rare for a municipality in the United States, and no other city matches the Cambridge proportion of human-powered means. Cambridge is different even from other cities with similar population densities.

About Cambridge

First settled as a town in 1636 and established as a city in 1846, Cambridge lies across the Charles River from downtown Boston. Harvard College (now University) in Cambridge also was founded in 1636, and at that time only a few roads connected the school to the villages of East Cambridge, Cambridgeport, and neighbors such as Arlington. As Cambridge's population grew, few additional major arteries were constructed. Today, Cambridge's 100,000 residents, living within 16.6 square kilometers (6.4 square miles), still are carried principally by those few routes, as are the 106,000 people who work in Cambridge, the annual 2.5 million tourists, and tens of thousands of people who simply pass through Cambridge on their way to and from other destinations.


CDD

Harvard Square, with all four corners easily accessible on foot, attracts a mix of students, tourists, residents, and businesspeople, helping to meet Cambridge's goal of sustaining diverse neighborhoods and thriving commercial areas.

Although students from the Massachusetts Institute of Technology, Harvard University, and other neighboring campuses comprise a significant portion of the community, Cambridge is not the typical college town. About 10 percent of the population is elderly. The city contains 2 centers for senior citizens and 7 buildings housing 50 or more seniors. These facilities will become even more important as the 45 to 65 age group, which has grown by one-third since 1980, begins to retire.

The city uses the Plan E form of government, also known as the "weak mayor" system because the city manager has executive powers. In addition, the mayor is not elected; rather, one of the nine elected members of the Cambridge City Council is chosen to serve under the title of mayor. Each neighborhood is represented by an association, again showing the close involvement of the citizenry in the city's affairs. Several council-appointed advisory

Multimodalism: A Comparison of City And State Commuters (Percentages)

Means of Travel	City of Cambridge	Commonwealth of Massachusetts
Drive Alone	35.3	73.8
Transit	24.9	8.7
Rideshare	5.2	9.0
Bike	3.9	0.4
Walk	24.3	4.3
Other	1.1	0.5
Work at Home	5.3	3.1

Source: Cambridge Traffic, Parking & Transportation Department.

Comparison of Multimodal Splits In East Coast Cities (Percentages)

Means of Travel	Cambridge	Boston	New York	Philadelphia	District of Columbia	Baltimore
Drive Alone	35.3	41.5	7.6	49.2	38.4	54.7
Rideshare	5.2	9.2	3.4	12.8	11.0	15.2
Transit	24.9	32.3	59.6	25.4	33.2	19.5
Bike or Walk	28.2	14.0	22.8	9.9	13.0	7.4
Other	1.1	0.6	0.8	0.7	0.7	0.8
Work at Home	5.3	2.4	5.8	1.9	3.8	2.3

Source: Census Transportation Planning Package.

committees meet every month, including separate committees and meetings for both pedestrian and bicyclist issues. Few major activities occur without input from the community.

Cambridge employs more than a dozen professionals in several departments who spend at least part of their time thinking about multimodalism. Some do so full time. Most of these professionals work in CDD's Environmental and Transportation Planning Division. This division has seven planners and two engineers, including a full-time project manager for traffic calming and a parking and transportation demand management (PTDM) officer. In addition, the Traffic, Parking & Transportation Department (TPTD) has two engineers and one planner. These professionals collaborate on all traffic calming, intersection, and streetscape improvement projects. On the enforcement side, the Cambridge Police Department includes 12 officers on bicycles. The police department aggressively enforces Commonwealth laws not only regarding vehicles failing to stop for pedestrians at crosswalks, but also the police stop cyclists who do not wear a helmet or use a headlight. Cambridge also has an ordinance requiring drivers to use care when opening a door into traffic, an effort to prevent "dooring" crashes involving bicycles.

"Close coordination among all relevant city departments has been critical to our success," says Rasmussen. "Monthly interdepartmental meetings with staff from [the Department of] Public Works; Traffic, Parking & Transportation; the Commission for Persons with Disabilities; and Community Development Department, as well as other departments on an as-needed basis, are key to making sure that roadway construction and repair projects capture opportunities to improve our streets and sidewalks for all users."

In some municipalities, for example, the public works department might not support the idea of traffic calming immediately, because curb extensions, for instance, impede snowplowing. Similarly, a fire department might oppose raised crosswalks because they reduce response times. But staff members from all of Cambridge's departments recognize the benefits of traffic calming and of working together generally, and are willing to discuss alternatives. The Cambridge Department of Public Works (DPW) and Cambridge Fire Department participate fully in the planning process.

Says Rasmussen: "From the beginning, the departments involved in designing traffic calming measures, such as curb extensions, raised devices, or chicanes [a set of two or three alternating curb bulbs or extensions that narrow a street], have worked closely with the [Cambridge] Fire Department to make sure that the proposed measures do not hamper emergency response. This review process, which often includes marking out the proposed devices and doing test runs with fire apparatus, has resulted in a very successful traffic calming program that is not in conflict with the need to respond quickly and effectively to emergencies."

Whether planning a single curb extension or a multimillion-dollar streetscape reconstruction, Cambridge officials consider impacts on and accommodations for pedestrians and cyclists at the start of each project. As a result, over time, Cambridge streets have incorporated these alternative modes of transportation.

Pedestrian- and Bicyclist-Friendly Programs

In addition to engineering and planning efforts, Cambridge uses dozens of other ways to ensure that walking and bicycling remain viable travel modes. Here are a few examples:

Snow exemption program. The Boston area receives about 1.1 meters (3.5 feet) of snow each year. Landowners are required to clear snow from public sidewalks abutting their property, which provides a continuous walking path safely off the street. Many elderly residents are physically unable to comply, so DPW performs the work when requested.

Traffic management at construction sites. Regardless of whether a project is public or private, the contractor must submit an engineering plan for the construction site. The plan must provide a temporary sidewalk, and often a bicycle lane, even if a parking or travel lane must be removed. Contractors are never allowed to close a sidewalk and force pedestrians to use the opposite side of the street.

PTDM. Each large employer in Cambridge is required to have a plan for helping its workers commute by

CDD

Massachusetts Avenue remains a major thoroughfare for Cambridge and its 100,000 residents. Here, at Harvard Square, more than 1,500 pedestrians cross the street in each peak hour.

CDD

This raised intersection replaced a traffic signal. In the mornings, this area is crammed with students walking to Morse Elementary School, just out of view to the left.

means other than driving alone. For example, employers might choose to employ strategies such as bicycle parking, shower facilities, emergency ride home programs, and rideshare matching, or incentives such as pretax deduction of transit and vanpool fares. The city's PTDM officer reviews the plans and works with the businesses to improve them when necessary.

In-pavement lighting. In one example of the city's willingness to explore new ideas, a developer installed flashing in-pavement lighting at a public crosswalk linking a building with a parking garage. Since then, city staff, residents, and developers have proposed several other ideas, such as an on-sidewalk "bicycle track" on the MIT campus and three traffic signals intended to control bicycle traffic, all of which have been built or are nearly complete, and some of which have been studied to measure their effectiveness.

Engineering Solutions

Cambridge residents have access to several shared-use paths within the city's borders. The community is bounded on the east and south by the Charles River, which is bordered on each riverbank by the Paul Dudley White Bicycle Paths. Another asset is the Minuteman Bikeway—the Nation's 500th rail-trail—that stretches from the Alewife neighborhood 17.7 kilometers (11 miles) northwest into the suburbs. A third rail-trail, the Linear Park Path, accommodates nonmotorized trips to Somerville, the neighboring city to the north.

Simple density is an important component of the modal split numbers. Aside from raw population density, Cambridge's four major commercial districts—Central, Kendall, Harvard, and Porter Squares—fulfill much of the public's needs within short walking or bicycling trips. The squares also are natural sites for the stations on the Massachusetts Bay Transportation Authority's red line subway.

But just having things nearby is not enough. If transportation practitioners expect people to walk or bike instead of drive, they must make the entire trip as safe, efficient, and inviting as possible. To do this, Cambridge has been diligent and meticulous in improving its infrastructure to encourage walking and biking—without a noticeable detriment to vehicle operations.

One infrastructure element important to safety is traffic signals. The Cambridge TPTD has set policy for intersections and enacted the following operational changes to 135 traffic signals throughout Cambridge:

Cycle length. Pedestrian delays increase with the cycle length of traffic signals. Cambridge engineers set the maximum cycle length to 90 seconds. At locations where an intersection has three or more phases, the city may use longer cycles, but never longer than 120 seconds. Although in most municipalities the ultimate goal is to minimize delay for vehicles, Cambridge does not seek to provide optimal vehicle level of service (LOS) and in fact considers "LOS D"—a condition where the influence of delay becomes more noticeable—to be acceptable. Rather, it aims to provide the best possible level of service for pedestrians as defined in the *Highway Capacity Manual 2000.*

Pedestrian signal operations. The policy sets pedestrian signals to operate concurrently with vehicle green lights, with leading pedestrian intervals (LPI) that provide a head start for pedestrians by turning on the "Walk" signal a few seconds before the green light is shown to vehicles. This short interval gives the pedestrian enough time to move several meters into the crosswalk. With the pedestrian already occupying the crosswalk, even the least considerate drivers have little choice but to yield before turning. Naturally, LPIs work best when the pedestrian volumes are higher. In Central Square, a truck-laden right turn is successfully countered by LPIs, and about 500 pedestrians cross in the peak hour of the morning. The LPI interval is 3 seconds long, and has what city officials deem a minimal effect on vehicle operations.

Countdown pedestrian signals. Cambridge officials decided to make

AAA Foundation for Traffic Safety

Construction at the road edge, such as this work being done in Washington, DC, can hamper bicyclists and pedestrians. In Cambridge, however, contractors are required to maintain easy, safe passage for all nonmotorized users.

CDD

Concurrent pedestrian phasing allows 60 seconds and longer for crossing in some Cambridge locations, as indicated by this countdown signal head.

the numerical countdown legend standard, along with light-emitting diode (LED) international symbols, in its pedestrian signal heads. The device displays the number of seconds remaining until the flashing "Don't Walk" interval ends, then disappears after 0 is shown. Engineers determine the duration of the flashing "Don't Walk" interval by assuming a walking speed, generally, of 1.2 meters (4 feet) per second. However, most people walk faster, and some are even willing to run. On the other hand, others, often the elderly, walk slower. The countdown legend enables the walker to decide if there is enough time to cross the street safely.

Because Cambridge has roughly 1,000 pedestrian signal heads and replacing all of them would not be feasible, the policy contains earmarks for upgrade locations with high pedestrian volumes and long "Don't Walk" cycles. Although little research has been done on the effectiveness of countdown signals, the public continues to request additional ones. The TPTD wants to phase in more such signal heads in the future.

Interaction With Senior Citizens

Cambridge's senior centers and senior living buildings often host members of the Cambridge City Council and their staff to discuss various matters, including traffic. At a recent "town meeting," the following were some of the most common comments from attendees:

Adequate time to cross the street is of utmost importance. Many elderly citizens reported that they are unable to walk as quickly and would appreciate longer crossing intervals. TPTD responded by extending the flashing "Don't Walk" time, assuming a walking speed of 1.1 meter (3.5 feet) per second in places with a high volume of elderly pedestrian traffic.

Pedestrians have a difficult time trusting the "Walk" indication if a car races past. Red-light running is a problem in Cambridge, and TPTD has employed several techniques to address it, such as increasing the all-red interval, increasing enforcement, and pursuing the use of red-light cameras.

Countdown signals are helpful, but the numerals can be hard to read. The numeral size on countdowns is fixed at about 25.4 centimeters (10 inches) high, and from across a wide street this size may not be legible to those with imperfect vision. The city is investigating emerging signal equipment products that provide larger legends.

LPI does not always result in yielding to pedestrians. This is a common complaint from all age groups. LPI works less well when pedestrian volumes are low or when turn radii are large. The latter can be remedied with improved design. For example, traffic calming techniques such as "neckdowns" (curb extensions at intersections) reduce the speed of turning cars, which improves the yielding rate.

More audible signals should be installed. Although the "chirp" and "cuckoo" tones are intended for the visually impaired, they can prompt the sighted as well.

Measures of Effectiveness

Using a multidisciplinary approach, officials with TPTD collected and analyzed crash data to study the effect that multimodalism might have on safety.

In 2004, 2,053 crashes occurred in Cambridge, or about 20 per 1,000 residents. In comparison, Massachusetts averaged 22 crashes per 1,000 residents, despite being 19 times less dense than Cambridge. The number of crashes in Cambridge has declined every year since 1998—the same year the first traffic calming device was installed—while statewide the number has remained steady.


AAA Foundation for Traffic Safety

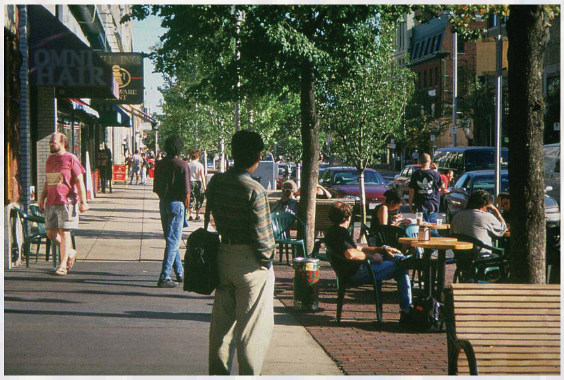
Clearly delineated bicycle lanes such as this one help improve nonmotorist safety across the country.

When comparing Cambridge's pedestrian crash rates to national and statewide rates, TPTD officials calculated rates using population as a denominator because there is no such measure as "miles walked." Therefore, comparing crash rates for the 100,000 Cambridge residents, who each make several walking trips a day on average, to 100,000 people elsewhere is an apples-to-oranges statistical dilemma. About 100 crashes involving pedestrians occur in Cambridge each year, steady since 1990. Assuming that the number of walking trips has grown since then, TPTD officials believe that the pedestrian crash rate—calculated using miles walked—has decreased.

Moreover, when crashes involving pedestrians in Cambridge do occur, they tend to happen at low speeds and result in few and minor injuries. The pedestrian accepts transport to a hospital in a little more than half of all crashes. In a study of 105 crashes between January 2004 and August 2005, every pedestrian but one was alert and was able to provide a report to the police officer at the scene. No fatalities were reported.

TPTD found no pattern in the causes of pedestrian crashes for January 2004 through August 2005, but TPTD officials were surprised that none involved a car running a red light, drunk driving, speeding, or young drivers (16- or 17-year-olds). The most common cause found was failure to yield, cited in 17 of the incidents. Just six crashes occurred when a pedestrian was using a "Walk" signal with the traffic green light, while nine involved jaywalking. A close look at bicycle crashes yielded similar results. Bicyclists also are involved in about 100 crashes per year. This number has remained steady since 1990 even while the number of bike trips has risen, a trend discovered through formal spot counts conducted by the city. A crash rate for bicyclists is equally difficult to calculate without a means to determine "bicycle miles traveled," but citywide the rate is likely decreasing.

An even smaller proportion of bicyclists than pedestrians is injured in crashes with vehicles. In a city study of 86 such crashes between January and November 2005, less than half accepted medical assistance, and there were no fatalities. Bicyclists striking opening car doors accounted for one quarter of all crashes. Adequately sized bike lanes help reduce these "dooring" incidents, and the city is always looking for opportunities to provide a 1.5-meter (5-foot) bike lane adjacent to parking. When space is limited, the city has found creative ways to separate parked and moving cars from bicyclists, such as bike "guide lines" and using "share the road" signs and road markings.



CDD

Where possible, removing vehicle lanes in favor of expanded sidewalks—and here in Cambridge's Central Square, providing space for outdoor seating for restaurants and trees for shade—helps create what some call more livable, sustainable cities.

TPTD continues to collaborate with the Cambridge Police Department on crashes involving pedestrians and bicycles. Also, TPTD updates its database with information from each detailed report it receives from the police and uses this information to propose and execute engineering changes on the street.

"We don't have the best luck with enforcement," notes Davis, the city councilor. "Cars park in the bike lanes. Drivers 'door' bicyclists. These are challenges—getting the police to see how much is at stake making the roads safe for walkers and bikers."

She adds, "We create partnerships with our citizens and other organizations to keep bikes and [pedestrians] high on the list, not invisible with only auto drivers acknowledged as the true travelers or commuters."

Drawing Conclusions

Creating a walkable, bikeable city is not the result of a single initiative or policy. Rather, it is a process that includes several city departments, elected officials, residents, and the business community, and it requires the cooperation of drivers, pedestrians, and bicyclists. As the vehicle population continues to grow faster than the human population, the challenge of sharing the limited street and intersection space grows increasingly difficult. In some cases, Cambridge has removed vehicle lanes in favor of bike lanes and wider sidewalks. Such a proposal might not receive due consideration in some cities, but the changing attitude in Cambridge of "peds and bikes first, cars second" elevates ideas like these from the drawing board to the conference room to the built environment.

The results in Cambridge show that the efforts of the city staff, residents, businesses, and many others have resulted in a city that is one of the easiest places to travel on foot and bicycle. In spite of the number of potential conflicts between vehicles and the large number of people bicycling and walking, serious crashes are rare.

Emerging engineering solutions are just pieces of the success. Most importantly, and by far the most difficult to achieve, is a far-reaching openness to serious accommodations to pedestrian and bicycling needs.

"Every driver is sometimes a walker or biker or transit commuter," notes Davis. "The best thing for all of us is to have a choice to use whatever mode we want."

Jeff Parenti is the principal traffic engineer for the city of Cambridge, which he has served for 5 years. Prior to that, he was the transportation engineer for Brookline, MA, where he started the town's traffic calming program, for which he received the Brookline Conservation Commission's Environmentalist of the Year award in 2000. He holds a BSCE from Carnegie Mellon University and an MSCE from the Georgia Institute of Technology.

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Saving a National Treasure

by Amy Vanderbilt and Steve Moler

FHWA and the National Park Service embark on a monumental restoration of Montana's historic Going-to-the-Sun Road.

(Above) Most of the guard walls along the Going-to-the-Sun Road near Triple Arches were either sheared off or damaged by avalanches and rockslides. Some of the old guardrails are visible in the foreground. As part of the restoration of the road, a new generation of removable steel-backed guardrails, seen in the background, are installed prior to the spring road opening and removed when the road closes in the fall so avalanches can travel over the road without causing damage. *Photo: NPS.*

The Going-to-the-Sun Road in Montana's Glacier National Park was once described as "the most beautiful piece of mountain road in the world." Those words, spoken by park Superintendent Eivind Scoyen to several thousand spectators at the road's 1933 dedication ceremony, will continue to ring true for many users now that a historic rehabilitation is underway.

The Sun Road, as some abbreviate it, is an 80.5-kilometer (50-mile), two-lane highway that winds through the heart of the park, up the steep slopes of the Continental Divide, and over 2,026-meter (6,646-foot) Logan Pass. Motorists can experience what some view as the most spectacular mountain scenery in North America—glacier-carved peaks, deep blue lakes, and lush forests.

The highway itself, built mostly between 1921 and 1937, is considered an engineering marvel by virtue of its designation as a National Civil Engineering Landmark. Most of the 19-kilometer (12-mile) "alpine," or high mountain, section over Logan Pass was built into the sides of near-vertical cliffs using a network of stonemasonry bridges, tunnels, and arches. A series of 130 retaining walls support the roadbed along the steepest sections, and more than 11 kilometers (7 miles) of guard walls and guardrails help guide motorists and keep them on the road. These stonemasonry guard walls give the road much of its historic character and architectural aesthetic appeal.

Today the Sun Road has more than 475,000 vehicles traveling it during Glacier's peak visitor season from June to October, or about 3,500 vehicles per day. Approximately 80 percent of the park's two million annual visitors travel the road, according to park surveys.

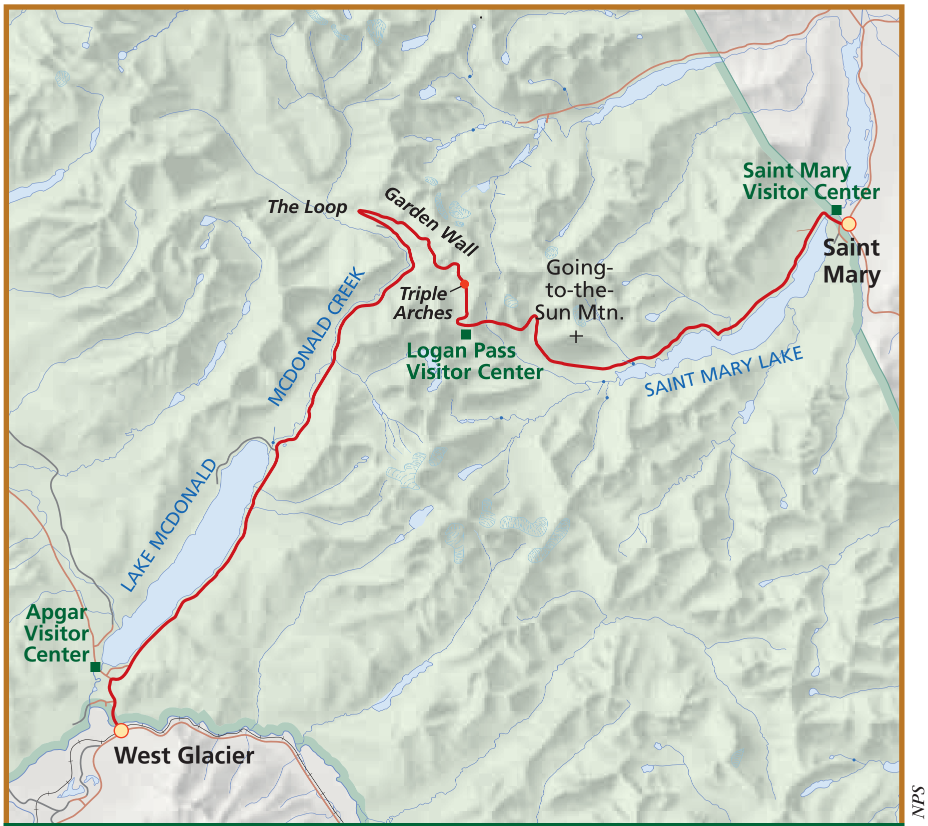
However, 70 years of rockslides and avalanches, severe weather, heavy traffic, and inadequate maintenance left the road in urgent need of repair. Without aggressive action, the historic structures for which the Sun Road is so admired might have been lost forever.

Preserving a National Treasure

The National Park Service (NPS) and Federal Highway Administration (FHWA) have embarked on a monumental rehabilitation project to save this national treasure. Indeed, the most urgent repairs on structures in danger of catastrophic failure were completed during previous phases. The two agencies originally intended to invest $140 million to $170 million over 7 to 8 years to restore the Sun Road's entire length. However, due to a lack of available funding, complete restoration could take 10 to 20 years. As a result, both agencies in partnership with local, State, and Federal officials are committed to completing the Sun Road rehabilitation under the earliest possible timetable, as funding allows. The effort involves repairing damaged and deteriorating stonemasonry retaining walls and guard walls, inadequate drainage systems, crumbling pavement, and tunnels and bridges. Safety improvements will be made at high-priority rockfall locations and at pullouts, overlooks, and parking areas. A comprehensive mitigation program will limit impacts on tourism.

"This is the largest and most complex project our office has ever undertaken," says Ricardo Suarez, project delivery director and acting division engineer for FHWA's Western Federal Lands Highway Division (WFLHD), which is jointly managing the project with NPS.

The project is also one of the largest road rehabilitations in NPS history, according to Glacier Superintendent Mick Holm. "The road is not the only jewel in the park's 'crown,' but a trip across the Sun Road does provide an iconic experience for a vast number of Glacier's visitors," he says. "The scope and magnitude of this project is clearly unprecedented and daunting. But I believe we can and must do nothing short of completing this rehabilitation in a timely manner, thereby preserving this phenomenal mountain byway experience for generations to come."



From east to west, the Going-to-the-Sun Road, shown here in red, starts in the village of Saint Mary, follows the northern shore of Saint Mary Lake, passes Going-to-the-Sun Mountain, climbs to Logan Pass, hugs the Garden Wall and turns the Loop, then follows McDonald Creek down to the southern shore of Lake McDonald, ending in the village of West Glacier.

A Monumental Task

The Sun Road rehabilitation actually began in the late 1980s at the village and park entry point of West Glacier. The remaining work involves about 13 construction phases in all. The first four, to rehabilitate the most severely damaged retaining walls, have already been completed through Park Roads and Parkways funding, a joint NPS-FHWA program to develop and maintain roadways throughout the national park system. Phase 5 was completed in 2005 and involved rehabilitating the West Side Tunnel's east portal and high-priority guard walls, correcting various drainage and roadside deficiencies, and repairing damage from a recent rockslide.

But it is the remaining phases that have turned the Sun Road work into an extraordinary project. Those phases involve rehabilitating the entire roadway itself and making the most critical and complex repairs to historic structures along the alpine section. Under a more typical schedule, this work would have been completed in small segments over a much longer period, but for economic and environmental reasons, NPS and WFLHD have decided to accelerate construction so the final phases can be completed more rapidly than past repairs.

The final phases were assessed under an environmental impact statement (EIS) and two records of decision (RODs), one by the NPS and the other by WFLHD. All the

A Road—and History—in the Making

The first tourists to visit what is now Glacier National Park came by train beginning in the 1890s. A typical trip involved getting off the train at the Great Northern Railway's Belton Station in present-day West Glacier, taking a 4.8-kilometer (3-mile) stagecoach ride to Lake McDonald, and then traveling by boat to the Lewis Glacier Hotel, now Lake McDonald Lodge. Guests also could go by horseback to backcountry lodges and chalets.

The automobile's proliferation at the start of the 20th century drastically changed the travel scenarios. By the time Congress designated Glacier a national park in 1910, many visitors already were arriving by private automobile via old wagon trails and dirt roads. Demand soon increased for a better road system that would allow enjoyment of the spectacular scenery without damaging the environment.

The concept was bolstered when Congress provided $100,000 annually in the early 1920s for construction of the "Transmountain Highway," as the Sun Road was first named. This was enough to start work on the road's flatter east and west ends in 1921. Construction of the more rugged central section over the Continental Divide loomed as a far greater challenge.

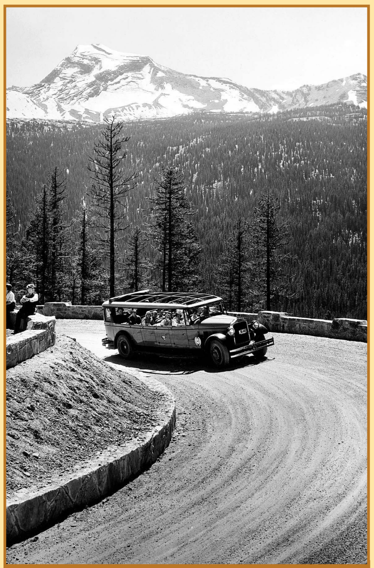
In 1918 NPS engineer and acting park superintendent George Goodwin had proposed a route similar to today's alignment, except that it included a steep climb over Logan Pass via 15 switchbacks and hairpin turns. Goodwin's proposal was typical of engineering at the time: It was fairly scenic, followed the shortest possible route, and above all was economical.

But NPS policy had come to stress the importance of "harmonizing park improvements with the landscape," and concerns about the plan were expressed during a route inspection in the summer of 1924. NPS Director Stephen Mather asked Thomas Vint, an agency landscape engineer, to review Goodwin's proposal. Vint said the switchbacks would look "like miners had been in there." Instead he proposed a road carved directly into the Garden Wall, a 4.8-kilometer (3-mile) section of nearly vertical cliffs near the summit of Logan Pass.

Vint's route was eventually chosen because it provided flatter grades, less environmental impact, better panoramic views, more sun exposure for faster spring snowmelt, and only one switchback—The Loop. The project received its second large cash infusion when Congress appropriated $1 million in 1924 and 1925 specifically for the Transmountain Highway.

In January 1926, NPS and the Bureau of Public Roads (BPR)—the predecessor agency to FHWA—signed a memorandum of agreement outlining how they would cooperate in building the road. The agreement combined BPR's high engineering standards and expertise with NPS's vision for preserving the landscape. It became the model for future national park road building and the basis for today's Park Roads and Parkways program, still a joint NPS-FHWA effort.

BPR soon accepted bids for construction of the western 19.3-kilometer (12-mile) stretch from Logan Creek up to Logan Pass, the most challenging section of the road and including Vint's route and single switchback. The construction firm (Williams and Douglas-Tacoma, WA) worked on the section for four seasons, building retaining walls, guard walls, Logan Creek Bridge, the West Side Tunnel, and Haystack Creek Culvert and Triple Arches.



NPS

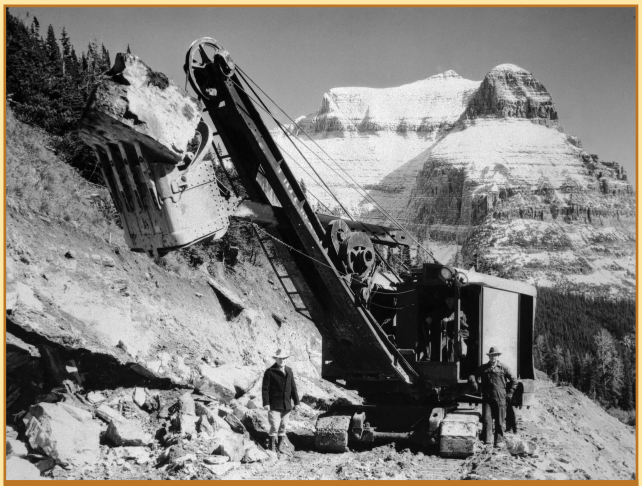
A historic red bus in the late 1920s rounds The Loop, the only switchback constructed on the Going-to-the-Sun Road. The entire fleet of original red "jammers" (so called by the locals because the drivers could be heard jamming the gears on the rugged mountain road) still operates in the park today.

NPS

Workers drag drainage pipes by horseback in 1927 during construction of the road west of Logan Pass.

Two other companies constructed the remaining 16 kilometers (10 miles) on the east side of Logan Pass in 1931 and 1932. The most difficult challenge was constructing the 123.5-meter (405-foot) East Side Tunnel. Workers had to carry out all the excavated rock by hand because power equipment could not reach the tunnel. One section was so remote that a power shovel had to be barged up St. Mary Lake to reach it.

In October 1932, after more than three decades and $2 million of construction, the first automobile drove the entire 80.5 kilometers (50 miles) of the new road, which was officially opened in a dedication ceremony on July 15, 1933. The road then was renamed after the nearby Going-to-the-Sun Mountain, which many think is the most aptly named road in the Nation given that motorists feel like they are traveling toward the sun as they ascend it.



NPS

A crew uses a power shovel east of Logan Pass in 1932. Going-to-the-Sun Mountain, for which the road is named, is seen in the background.

Many retaining walls, like this one near Crystal Point, are being "re-pointed," the process of removing and replacing damaged and deteriorated mortar. Here a crane lowers a worker, enclosed for safety in a cage-like basket, to perform repairs.

work will be done while the road remains open during the normal tourist season. The RODs were based on an accelerated rehabilitation schedule and were dependent on projections of increased project funding from the Park Roads and Parkways program; a congressional earmark from the new transportation reauthorization bill, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users; and other sources.

"I compare the Sun Road rehab to the restoration of the Statue of Liberty in the mid-1980s," says Ron Carmichael, former WFLHD division engineer who worked on the project during most of its early planning until retiring in September 2005. "Like the statue, the Sun Road is a national treasure that has fallen into disrepair. It is our obligation to rehab the road in a way that replicates the intent of the original constructors while preserving the historic and cultural resources and the visitor experience that was originally intended."

Many Challenges Ahead

Construction on the remaining phases is expected to be complex and challenging, according to engineering studies. Work can be done only 5 to 6 months of the year, typically mid-May to mid-October, because of harsh weather and the annual winter road closure. The terrain where much of the work will be performed is steep, and the roadway is extremely narrow, less than 6 meters (20 feet) wide along many stretches. Adding to the difficulties is the requirement that the road remain open throughout the entire rehabilitation. Finally, its designation as a National Historic Landmark requires NPS and WFLHD to minimize harm to the road's historic character and fabric in accordance with the Secretary of Interior's Standards for the Treatment of Historic Properties and related Federal and State regulations.

Rehabilitation will focus on five high-priority engineering areas:

Retaining walls, arches, and tunnels. Many of the road's stonemasonry retaining walls suffer from structural deterioration, primarily from age and impacts from rockslides, vehicles, and avalanches. Damage also has been caused by rain and snowmelt repeatedly freezing and thawing inside and behind the walls. Thirteen retaining walls, determined by WFLHD to be in immediate danger of catastrophic failure, were repaired in the first four phases. Remaining problems include decaying and inadequate foundations, poor embankment stability, inadequate drainage, and the breakdown of mortar (the binding that holds the stones together).

To solve these problems, many sections of retaining walls either have been or will be "repointed" with new mortar. In more severe cases entire walls will be rebuilt. Some retaining walls will be preserved by building second, hidden walls behind them to carry some of the structural load.

Guard walls and removable guardrails. Many sections of the road's stonemasonry guard walls have suffered damage from age, impacts from vehicles, avalanches, and rockslides, and improper repairs over several decades. As with the retaining walls, water seepage has caused cement on some guard walls to leach out from the grout. Some guard walls have just a few stones broken or missing, while parts of

FHWA Resident Engineer Margaret Moen, who worked on the project until early 2006, inspects a construction site where a new and hidden concrete retaining wall was constructed inside the original wall, allowing the historic wall to maintain its original appearance without having to support its former structural load.

others have been sheared off or are leaning precariously over cliffs.

Entire sections of guard wall will have to be completely reconstructed in the most severe cases. In others, missing stones can simply be replaced. To meet current safety standards for guard wall height, either the walls will be raised or the road grade lowered.

For decades, finding a reliable and high-quality supply of historically compatible stone has been a challenge. Having assessed surrounding quarries, WFLHD and NPS currently are evaluating three possible sites with the required stone—Helena Formation limestone—with a preferred site expected to be chosen soon.

The Sun Road has 70 documented avalanche chutes where stonemasonry guard walls are susceptible to damage. Over the years NPS has installed various types of removable timber guardrails so avalanches pass over the road without causing damage. However, the original log rails of the 1930s were not crashworthy in that they did not withstand vehicles hitting them and over time were found to crowd travel lanes as larger vehicles began using the road. Also, the high maintenance costs of removing the rails in the fall and reinstalling them each spring prompted NPS and WFLHD to seek other options.

Recent projects have used a new generation of removable guardrails that have been crash-tested and designed to protrude no farther into the travel lane than the guard walls. The new rails are more historically authentic and aesthetically pleasing to many than their predecessors.

New avalanche-resistant guard walls have been constructed with a reinforced concrete foundation and core, then finished with a historically compatible stonemasonry facing. A concrete slab anchored with small piles (micropiles) was laid within the roadway underneath the new guard wall, and the concrete colored to match the adjacent asphalt pavement. Two prototype guard walls performed well in a winter 2004 demonstration project, according to former WFLHD Project Manager Dick Gatten, who retired in January 2006. Each avalanche site, he says, will be evaluated to determine whether a resistant guard wall or removable guardrail will be installed.

Drainage. Many of the road's original drainage systems are still functioning as designed, but some added after the road was paved in the 1950s now suffer a variety of problems, from broken and separated pipes to crumbling stonemasonry headwalls. All historic structures slated for repair or rehabilitation will be designed with new drainage features to minimize water seepage and other damage due to the harsh climate. Structures not needing repair will have their drainage systems evaluated and rebuilt if necessary, with enlarged culverts.

Slope stability. Rockfall safety hazards are present along the steepest road sections because of unstable slopes and rock cuts, according to engineering studies. The roadway is also "creeping" (shifting) because of drainage problems, fill settlement, and avalanches.

Removing rockfall hazards within the original cut will involve selective rock scaling, the process of removing potentially loose and unstable

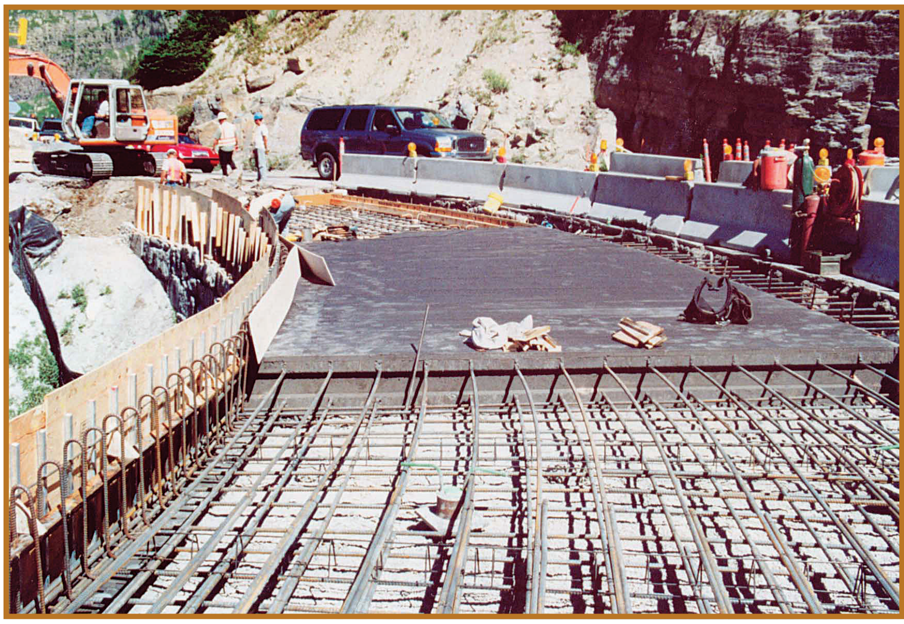
NPS

Over the years, avalanches, such as this one that took place on May 22, 2003, at Haystack Creek, have ripped up pavement, sheared off guard walls, and caused other road damage at 70 known avalanche chutes along the Sun Road.

slabs and outcrops before they crash down on the roadway. Those that are too large to scale will be bolted or anchored to more stable rock foundations. Also, to help support unstable rock, holes are drilled below the rocks that are to be stabilized; steel dowels are inserted; "shotcrete," a type of concrete, is applied under pressure between the rocks and dowels; then the shotcrete is shaped, textured, and colored to match its surroundings. Slumping or creeping roadways will be evaluated and, if necessary, corrected with drainage improvements, retaining wall construction, reinforced earth, tieback anchors, and micropiles.

Pavement. The roadway in many locations has deficient subgrade and road base, and along many other sections the surface is damaged and

Masonry workers are attaching a historically compatible stone veneer to a new concrete retaining wall near Triple Arches.



As shown in this photo, more durable and longer-lasting reinforced concrete pavement is being installed in rockslide and avalanche-prone areas such as this site just east of Triple Arches.

uneven. Solutions involve subexcavation to remove and replace unsuitable subgrade and road base material, as well as laying new pavement. Damaged or uneven pavement will be repaired and repaved. Remaining sections will be resurfaced.

Success Starts With Careful Planning

A project of this magnitude requires years of intense and collaborative planning. The process for completing the final phases on a faster-than-normal schedule began in the mid-1990s, when NPS and WFLHD launched a retaining wall management program to identify, evaluate, and monitor the Sun Road's 130 retaining walls. Having found serious structural problems in many of the walls, the agencies collaborated on various studies and initiatives in the late 1990s and early 2000s that led to the decision to rehabilitate the entire road—and as quickly as possible to prevent catastrophic wall failures and minimize impacts on the park and its visitors.

One initiative during the planning process involved forming a congressionally authorized Citizens Advisory Committee in February 2000 to help NPS develop initial alternatives that were considered in the project's EIS. In addition to potential environmental and social impacts, the committee had to consider other issues, including project costs, scheduling, and historic preservation.

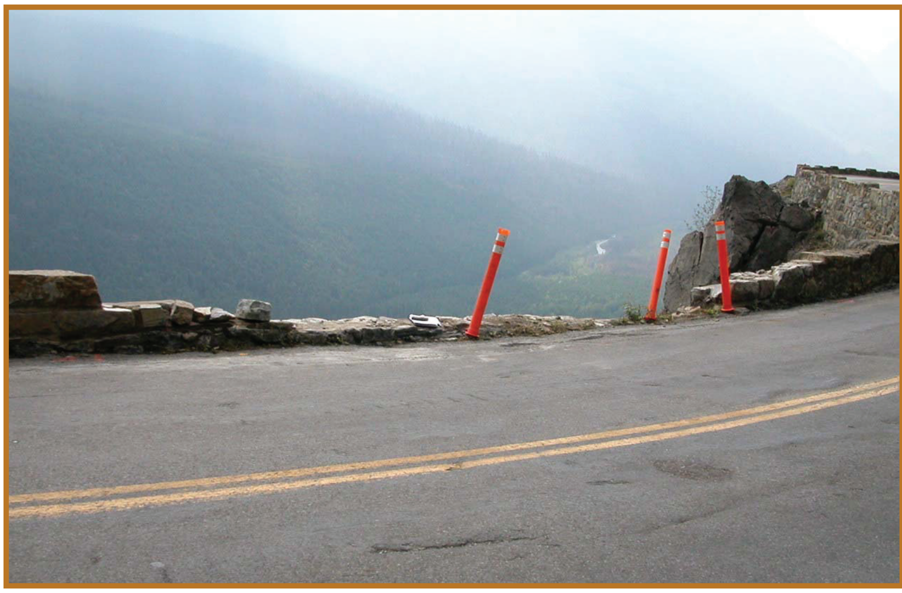
A major goal of the rehabilitation is maintaining the quality of the visitor experience, particularly during construction. Glacier is a world-famous destination that accounts for much of the region's tourism. A sudden dramatic drop in visitation because of intense construction along its most popular sightseeing route could result in undesirable economic consequences. The committee spent about a year and a half developing five recommended alternatives. All but one of the alternatives were analyzed in the project EIS as follows.

Alternative 1: Repair as Needed or No Action. Under this option, rehabilitation would continue as funding allowed over 50 years at an annual cost of $7 million to $8 million. Work would primarily focus on critical and emergency repairs without substantial long-range planning. This alternative was rejected because the badly needed repairs would not occur soon enough to preserve and protect the features and character of the Sun Road as a National Historic Landmark.

Alternative 2: Priority Rehabilitation. Rehabilitation would occur over 20 years, with total funding at $157 million to $186 million, or about $8 million to $9 million per year. The road would remain open to visitors, and a maximum cumulative delay of 30 minutes would be allowed when traveling the Sun Road's entire length. This option would allow for advance planning to rehabilitate high-priority sites and would address current structural road deficiencies but with only a few improvements to visitor facilities, such as turnouts, parking areas, and walkway access to interpretive sites. This option was not selected because repairs would not occur soon enough, resulting in continued road deterioration, loss of historic features, possible damage to natural resources, and greater economic impacts than Alternative 3.

Alternative 3: Shared Use With Extended Rehabilitation Season. Rehabilitation would occur over 7 to 8 years at a total cost of $140 million to $170 million, or about $18 million to $24 million per year, provided the needed funding would be available or unforeseen delays did not occur. This alternative would accomplish the needed road repairs while maintaining visitor use and access to the Sun Road. Roadwork would be conducted throughout the visitor season, but work requiring substantial traffic delays would occur during the shoulder season, the time prior to mid-June and after mid-September. Otherwise, a maximum cumulative delay of 30 minutes would be allowed when traveling over the length of the road between mid-June and mid-September, the peak season. Up to 1 hour of cumulative delays over the length of the road would be possible during nonpeak hours in the mornings (8 a.m. to 10 a.m.) and evenings (3 p.m. to 8 p.m.), Monday through Thursday. Variable traffic delays would be used for night work, with advance notice to the public of the construction schedule.

Alternative 4: Accelerated Completion With Isolated Road Segment Traffic Suspensions. The objective of this alternative would be to complete the rehabilitation as soon as possible by using isolated traffic suspensions Monday through Thursday from the months of May through October. Visitor access would be maintained on the weekends. This alternative planned



NPS

The three orange safety markers demarcated a section of guard wall that has been sheared off by repeated vehicle impacts. This guard wall will be reconstructed with new and stronger footings and historically compatible stone.

for repairs to be completed in 6 to 8 years at a cost of $126 million to $144 million, or $16 million to $24 million per year. Alternative 4 contained the same visitor use improvements and visitor development mitigation funding as Alternative 3. Because of the faster rate of repair, Alternative 4 would have minimized further deterioration to the Sun Road and historic, cultural, and natural resources. However, it would have the greatest impact on park visitation and annual impact on the local economy. Therefore, Alternative 4 was rejected.

Preferred Alternative—Open for Business

During the EIS process, which included extensive public involvement through meetings, open houses, and a 60-day comment period, NPS and WFLHD selected Alternative 3 (Shared Use) as the best option. After some small changes, Shared Use was documented and approved in the NPS's ROD in November 2003 and WFLHD's ROD in March 2004 because it provided the best balance of protecting historic, scenic, and natural resources while minimizing economic impacts.

Since the final EIS and documentation in the RODs, the anticipated funding levels required to complete the entire repairs in 7 to 8 years did not become available. Consequently, NPS and WFLHD are jointly developing a strategy that will include public involvement and repair of the Sun Road in the earliest possible timetable, as available funding allows.

Keeping Business as Usual

These strict road-closure limitations and the need to reduce traffic congestion became the driving force behind development of a comprehensive mitigation program. How to keep 3,500 vehicles moving through a major construction zone every day on a narrow, steep mountain road without causing gridlock was one of the biggest challenges from the outset, according to Superintendent Holm. "During the next decade, visitors driving over the Sun Road are going to see more construction than normal," he says. "So we needed to take measures to mitigate this. We want to make the driving experience as enjoyable and trouble free as possible."

One of the first efforts toward this goal was completion of a construction sequencing strategy that details when and how all pieces of the rehabilitation puzzle will fit together to minimize traffic congestion and delays. The strategy calls for construction to progress generally from west to east where traffic will

NPS

Crews at the site shown here excavated the original retaining wall (at the far right) down to bedrock in preparation for reconstruction. They constructed a temporary retaining wall between the original retaining wall and the Jersey barrier to stabilize the work zone while they were reconstructing the historic retaining wall.

be reduced to one lane most of the time. Temporary traffic signals, vehicle-actuated devices set on fixed cycles for times other than the actual work period, will be installed at each end of most work zones to control one-way traffic. During the work periods, flaggers usually will work in two-person teams, one to control traffic and the other to walk the lines of stopped vehicles to answer questions and provide information.

WFLHD is using a traffic modeling computer program called QuickZone to predict traffic impacts at each work zone. The program can estimate traffic backups, delay times, and optimum construction schedules, and can estimate impacts resulting from construction schedule changes, flaggers, and signal timing.

Leave the Driving to Glacier

Another key component of the mitigation program is a new voluntary transit system. Visitors will still be able to drive their own vehicles over

NPS

These renderings show the interior and exterior of a new transit center that will be constructed near Apgar Village at the park's west entrance. This transit center, and another adjacent to an existing visitors' center at the park's east entrance, are part of a new Glacier shuttle bus system designed to minimize traffic congestion during construction.

NPS

the road as usual, but they will have the option of leaving their cars at two transit centers—one at each end of the park—and taking regularly scheduled shuttle buses to the Sun Road's most popular destinations, such as trailheads, overlooks, and interpretive sites. The system will be phased in over two seasons, with initial service covering a limited area starting in summer 2007 and the whole system scheduled to be fully implemented over the entire Sun Road by summer 2008. The transit center near the west entrance will be a new facility featuring a building where riders can obtain transit and road project information, a sheltered pickup and dropoff area for riders of the shuttle buses, and parking for about 150 vehicles.

A Federal, State, and local partnership has been established to purchase and operate the shuttle bus fleet during both the construction and off-seasons. The off-season program will help meet other Montana-wide transit needs and make the entire transit system more cost effective. This partnership with the Montana Department of Transportation will leverage existing Flathead and Glacier County maintenance facilities, provide year-round employment in local gateway communities, and reduce the direct burden on FHWA and NPS for operating and maintaining the system.

"We are really encouraging our visitors to use the transit system whenever possible, once it's up and running," says Superintendent Holm. "Our goal is to reduce vehicle traffic on the Sun Road by 10 percent. If we can reach this goal, I think the driving experience will be enjoyable for everyone, whether you decide to drive, take an interpretive tour with either Sun Tours or aboard the historic red buses, or take a shuttle bus."

Smart Transportation System

The entire Sun Road mitigation program will be supported by an extensive intelligent transportation system (ITS) computerized communications network that will provide real-time information to visitors regarding road conditions, parking availability, traffic, weather, transit schedules, and more. For example, travelers planning a trip to Glacier, or en route to the park, will be able to receive construction information via the Internet, highway advisory radio, Montana's 511 telephone traffic information system, and variable message signs strategically located inside and near the park.

Other features to enhance the visitor experience include new interpretive signs and exhibits at transit stops and other strategic locations that tell the story of the park's history, wildlife, plant life, and the construction of the original Sun Road. Several locations will have interactive information kiosks.

The Beginnings of Context Sensitive Solutions

A modern-day construction principle may be traceable specifically to 1924 and NPS. In that year, NPS's first director, Stephen Mather, sought help from BPR on Glacier National Park's Transmountain Highway project, saying it warranted the "best engineers and the best landscape architects in the country."

Under a January 1926 memorandum of agreement, BPR and NPS landscape engineers (landscape architects) worked together on road plans that blended the highway into the surrounding environment while meeting other objectives such as safety and capacity goals. "This is an early example of what is now called "Context Sensitive Solutions," according to NPS Landscape Architect Jack Gordon.

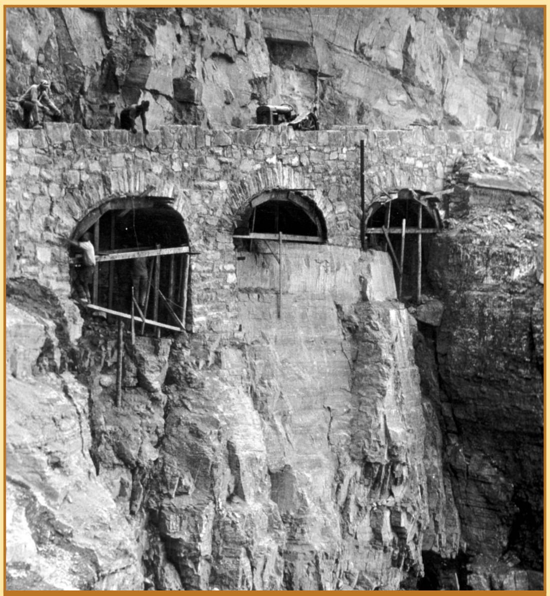
NPS Landscape Engineer Thomas Vint, who was associated with numerous park developments throughout his extensive career, wrote to NPS Chief Landscape Engineer D. R. Hull: "Construction details such as bridges, tunnels, retaining walls, parapets, culverts, etc., should not be monumental or stylistic but native, simple in line, and retiring."

Bridges, retaining walls, and guard walls were all constructed of native rock excavated from initial road cuts and roadside quarries. Different stone colors, including red and green argillites and buckskin limestone found along the alignment, were reflected in adjacent guard walls.

This practice established a unique appearance and a precedent for other national parks to follow. It fulfilled the desire of landscape engineers to "fit foreign, manmade works as an inconspicuous, homogeneous part of the natural scenery," according to Gordon.

Other environmentally friendly practices included the requirement that contractors use the least destructive blasting techniques possible, and crews were prohibited from "side-casting," dumping excavated materials over the roadside to the terrain below. Spoils were used as fill material whenever possible, and unsuitable material had to be properly dumped in designated locations.

This sensitivity to surroundings may be best expressed in the Triple Arches, arguably the most renowned structure along the Sun Road. Originally, Triple Arches was not even in the road's plans, according to the Historic American Engineering Record, where NPS road records are archived. NPS and BPR originally wanted to bridge a gap in the mountainside at the site of Triple Arches by constructing a large retaining wall and building up the roadbed with huge amounts of fill material. But the contractor came up with the more innovative three-arch design.



A large retaining wall was originally planned for the site at Triple Arches, shown here. After construction started, the contractor obtained approval to build the more attractive triple-arch structure. But for all its engineering innovation, Triple Arches also mistakenly incorporated a design flaw: The westernmost arch, on the far left, was built with its spring line—the imaginary line connecting the bottom of the two ends of the arch—parallel to the road's 6-percent grade, rather than horizontally. This was corrected in the remaining two arches. *Photo: NPS.*

In addition to ITS technologies and enhanced educational services, the mitigation program will mount a comprehensive public information effort, identified by the advisory committee as an essential element in the Sun Road rehabilitation. This initiative will provide timely and accurate information through a variety of sources, such as the Internet, travel and tourism guides and magazines, the news media, brochures and signs at surrounding communities, gateway tourism and travel businesses, and public service announcements. The public information and outreach also will include customer service training for frontline employees about the project and related services.

The extraordinary effort that NPS and WFLHD are making to maximize the Glacier National Park experience throughout the entire construction project gives visitors added opportunities to witness history in the making—the preservation of a national treasure.

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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 6 years, providing the agency's field offices and partners with support in media relations, public relations, and public involvement communications. He can be reached at 415-744-3103 or steve.moler@fhwa.dot.gov.

The authors would like to thank Jack Gordon, Glacier's landscape architect, for his substantial contribution to this article. For more information on the Going-to-the-Sun Road rehabilitation and road status, go to www.nps.gov/glac/sunroad/whatsup.htm or www.nps.gov/glac/montana.htm. The 511 Traveler Information and QuickZone are two of the FHWA priority, market-ready technologies, which are innovations that have proven benefits and are ready for deployment (see www.fhwa.dot.gov/crt/lifecycle/ptisafety.cfm).

Transportation professionals employ audits to scrutinize roadways for safety issues—and reduce crashes, injuries, fatalities, and costs in the process.

RSAs For Safety.

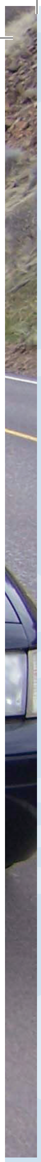
by Louisa Ward

(Above) In this photo from Oregon, a team of transportation professionals confers during a road safety audit (RSA) on a stretch of U.S. 97.

For more than 10 years, the number of fatalities on U.S. roadways has remained at a plateau of about 42,000 deaths annually. Although the fatality rate on U.S. roadways has decreased remarkably to 1.46 deaths for every 100 million vehicle miles (MVMT) traveled, further improvements are vital. The number and rate of deaths are unacceptable to the Nation, the Federal Highway Administration (FHWA), and partners such as the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE), the National Association of County Engineers (NACE), and the American Public Works Association (APWA).

In 2005, nearly 3 million people were injured and some 43,200 killed on U.S. roadways. That means there were 117 traffic fatalities every day on average, including one road departure fatality every 21 minutes, one intersection fatality every hour, and one pedestrian fatality every 2 hours. There are economic implications as well: a "societal cost" of $230 billion annually, or $630 million daily, according to FHWA.

One of numerous initiatives to reduce the crash rates is FHWA's promotion of road safety audits (RSAs) as a proactive means of reducing deaths and injuries. FHWA first studied RSAs in 1996 in a 2-week "scan" of audits in Australia and New Zealand (see the September/October 1997 issue of PUBLIC ROADS).



What Is an RSA?

An RSA is a formal examination of the safety performance of a roadway or intersection by an independent, multidisciplinary team of transportation professionals. RSAs are a comprehensive and effective tool for proactively improving road safety while a facility is still in the planning or design stage, or for identifying and mitigating safety issues on existing roadways.

Identifying a problem before it becomes part of the infrastructure is a preferable approach. As a manual on RSAs by Austroads, an association of road transport and traffic authorities in Australia and New Zealand, indicated: "It is easier, quicker, and cheaper to change a pencil line on a drawing than to move concrete and asphalt after the job is built."

FHWA's Office of Safety, Office of Infrastructure, Resource Center, and Highways for LIFE (HfL) team work with AASHTO's Technology Implementation Group to champion RSAs. The HfL team assists the FHWA Office of Safety with marketing expertise and funding to speed implementation of RSAs across the country, building on the inroads already made. The purpose of the HfL program is "to advance *l*onger lasting highway infrastructure using *i*nnovations to accomplish the *f*ast construction of *e*fficient and safe highways and bridges" (thus spelling out "LIFE"). HfL uses "innovations" as a broad term to cover technologies, materials, tools, equipment, procedures, specifications, methodologies, and processes or practices used in the finance, design, or construction of highways.

Many State departments of transportation (DOTs) have shown increased safety resulting from the process. "The road safety audit process looks at the roadway from a purely technical safety viewpoint without outside influences," says Ricky Lee May, district engineer with the Mississippi Department of Transportation. "It is a valuable process that gives an unbiased view of safety issues with support from safety experts."

In short, RSAs can make safe roads even safer.

The Basics

Most DOTs have established traditional safety review processes through their high-hazard identification and correction programs. However, an RSA and a traditional safety review are different processes. Generally, an RSA involves more people from more disciplines who are looking only at the issue of safety and have not been involved in the project's design or implementation. This approach allows for greater objectivity and a fuller report on a roadway's safety problems.

RSAs help produce designs that may reduce the number and severity of crashes, promote awareness of safe design practices, and reduce costs by identifying safety issues and correcting them before projects are built. Highway authorities formally respond to the suggestions of the RSA team and either

States on the Move

Several State DOTs and local agencies have incorporated RSAs into their existing efforts to enhance safety. The following sampling highlights a few RSA programs around the country without being an all-inclusive list. Looked at in conjunction with activities in other States such as Florida, Illinois, Michigan, South Carolina, Wisconsin, and elsewhere, the list demonstrates that the momentum for RSAs is building.

- In Iowa, RSAs are conducted on "3R" (rehabilitation, restoration, and resurfacing) pavement projects. "Iowa DOT [Department of Transportation] has implemented road safety audits on proposed resurfacing projects," says Tom Welch, Iowa DOT's State transportation safety engineer. "Previously, very few safety improvements were incorporated into our resurfacing projects. We now see that our staff consistently look for and implement numerous low-cost safety improvements on Iowa's roads."
- In Kansas and South Dakota, RSAs are conducted on existing roads.
- The Maine Department of Transportation drafted a policy to institutionalize the RSA program into its project development process.
- The New Jersey Department of Transportation and South Jersey Transportation Planning Organization are each conducting RSAs.
- The New York State Department of Transportation integrated RSAs into its pavement overlay program.
- The Pennsylvania Department of Transportation (PennDOT) was the first State DOT to start an RSA program. "PennDOT has found that RSAs are a valuable, low-cost tool that enhances the safety of a project by providing unbiased early recommendations for the project based on safety and multimodal needs," says Girish N. Modi, safety management division chief of PennDOT's Bureau of Highway Safety and Transportation Engineering. "We intend to make RSAs an easily and frequently used tool in the design process."
- The Standing Rock Sioux Tribe in North Dakota and South Dakota has conducted two RSAs.
- The Tennessee Department of Transportation is conducting one RSA every 2 weeks on existing roads.
- The Vermont Agency of Transportation is working with regional planning agencies to conduct RSAs of existing roads.
- The Virginia Department of Transportation is conducting an RSA on one of its highways.
- In Arizona, a statewide RSA program was established through the Governor's Traffic Safety Advisory Council RSA Subcommittee. There is representation from regional planning agencies, local jurisdictional agencies, enforcement agencies, academic institutions, State DOTs, the Governor's Office of Highway Safety, and FHWA. Therefore, with this multidisciplinary team, the results will be comprehensive and cross jurisdictional lines. Some of the major accomplishments of the subcommittee thus far have been hiring an RSA manager at the State DOT who will facilitate the development of RSAs statewide on all public roads. RSA training will be delivered throughout the State, and the RSA manager will work with the locals and tribes in implementing RSAs on roadways not owned by the State. The RSA program will utilize Highway Safety Improvement Program and Section 402 funds, HfL for marketing, and peer-to-peer resources.

Road Safety Reviews Versus Road Safety Audits

Traditional Safety Reviews	RSAs
Performed by a safety review team that is usually not completely independent of the design team.	Performed by a team independent of the project.
Typically performed by a team with only design and/or safety expertise.	Performed by a multidisciplinary team.
Often concentrate on motorized traffic.	Consider all potential road users.
Do not normally consider human-factor issues.	Account for road user capabilities and limitations as essential elements of an audit.
Often do not generate a formal report.	Always involve generating a formal RSA report.
Often do not generate a formal response report.	Always include a formal response report.

Source: Road Safety Audit Guidelines *(FHWA-SA-06-06).*

implement its suggestions or document the reasons for not doing so.

The keys to success in implementing an RSA program are top-level agency support, willingness to incorporate findings, and willingness to investigate new ideas outside the traditional scope of work. The small, multidisciplinary audit teams should include members from the highway/traffic safety, traffic engineering, planning, operations, geometric design, construction, maintenance, human factors, or enforcement fields. Also integral to success is conducting RSAs at the earliest possible stage of project development.

Evaluation of RSA Results

Evaluation of RSAs has been more extensive in Australia and New Zealand than in the United States. Austroads has documented favorable benefit/cost ratios for RSAs, but the early returns on RSAs in the United States are positive as well. For example, Terecia Wilson, safety director for the South Carolina Department of Transportation (SCDOT), sees a beneficial impact from the State's program: "We view RSAs as a proactive, low-cost approach to improve safety," she says. "The RSAs helped our engineering team develop a number of solutions incorporating measures that were not originally included in projects. The very first audit conducted saved SCDOT thousands of dollars by correcting a design problem."

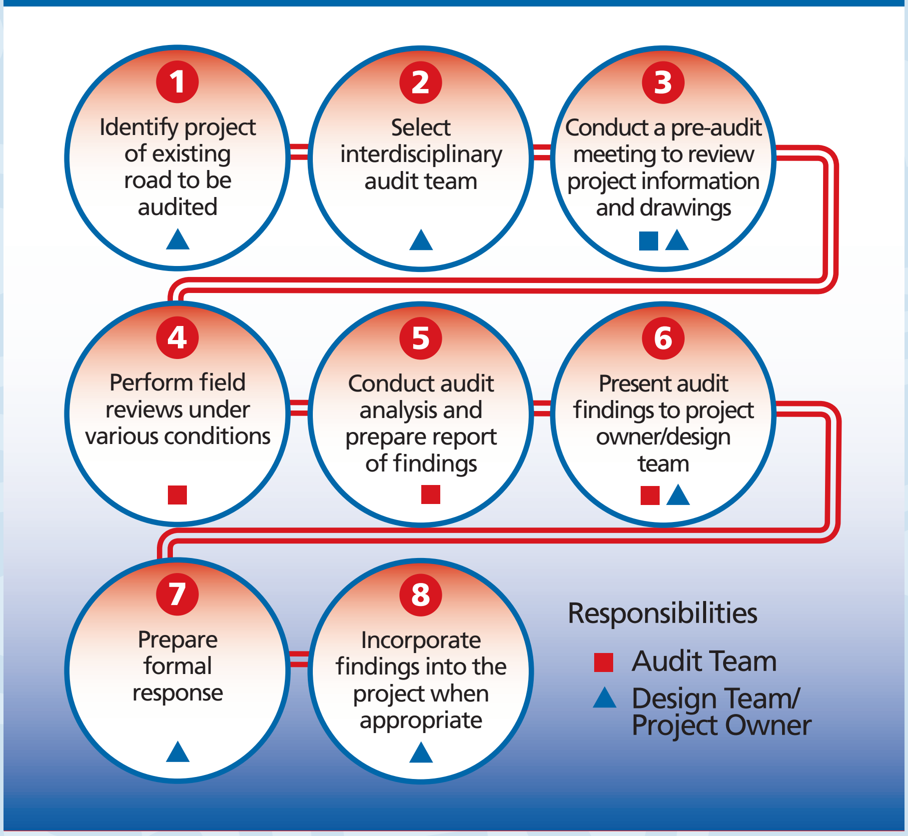
SCDOT has conducted six RSAs since 2003. The results of these RSAs (two of them are described below) are now available, and while SCDOT officials acknowledge that the findings are preliminary, they believe that the numbers are promising. In the RSA of SC–14 in Greenville County, SC, nine safety improvements were suggested, and all were implemented. Fatalities on that highway were reduced by 60 percent from 2003 to 2004, avoiding more than $3.6 million in estimated potential economic losses. In Spartanburg County, an SCDOT audit of SC–296 in 2003 led to a 23.4-percent reduction in crashes in 2005. Of 37 safety recommendations, 25 were adopted, and the economic benefit is estimated at $147,000.

In Michigan, a public-private partnership was formed to improve intersection safety. The partnership included AAA Michigan, the city of Detroit, city of Grand Rapids, Wayne County, Michigan DOT, Southeast Michigan Council of Governments, the Michigan Office of Highway Safety Planning, and Wayne State University. The partnership conducted RSAs on 250 intersections in Detroit and Grand Rapids. Of those, more than 80 have been evaluated. Collectively, these intersection improvements resulted in a more than 25-percent reduction in total crashes and more than 40-percent in injury collisions. The benefit/cost ratio exceeded 16 to 1 over 10 years.

RSAs in Practice

In late 2004, FHWA's Office of Safety initiated a series of 10 RSAs that will be documented in a book of case studies to show the variety of applications in different parts of the country, on different roads and intersections, and at different stages of the

Steps in an RSA Process



These before (left) and after (right) photos depict the intersection of 7 Mile Road and Dequindre Road in Detroit, MI. An RSA in 2002 led to, among other changes, placement of a left-turn arrow on the pavement to improve roadway navigation and safety. *Photos: AAA Michigan.*

project development process. The full report, containing summaries of RSAs conducted by the Oklahoma Department of Transportation (DOT); Clark County, WA, DOT; the city of Cincinnati, OH, transportation department; the Standing Rock Sioux Tribe transportation department in North and South Dakota; plus those listed below, can be found on FHWA's Web site in early winter 2007: http://safety.fhwa.dot.gov/rsa.

Illinois. The Illinois Department of Transportation (IDOT), which uses the term "assessments" instead of "audits," uses RSAs as a tool to look at locations that have had a history of severe crashes and to identify safety issues, their risks, and potential low-cost countermeasures. Sample findings from the RSAs include signage issues, existence of vulnerable users (pedestrians and bicyclists), turning-radius issues, signal displays out of alignment, clear-zone violations, drainage grates that are unfriendly to bicyclists, trees in medians showing evidence of being struck, exposed culverts, and openings in guardrails. IDOT has hosted three RSA training courses taught by FHWA and plans to host one in each of the State's districts.

Yellowstone National Park. In May 2005, an FHWA team conducted an RSA in the Old Faithful area of the park, specifically from Black Sand Basin to Kepler Cascades. Currently, traffic conflicts occur between pedestrians and vehicles after each eruption of the geyser, and issues also exist with signage and the geometry and operation of one of the park's overpasses. The short-term mitigation measures identified during the RSA include changing the traffic flow to reduce posteruption conflicts, developing signing and way-finding plans, and providing a shoulder plus exclusive merge/diverge lanes at the overpass. Longer term remedies suggested include using roundabouts, considering older-driver needs, maintaining

S.C. Stands for Scrutiny and Concern

For an idea of the exacting nature of RSAs, one needs to look no further than SCDOT District 3. In June 2003, a three-person team from outside the district, with expertise in road design and traffic engineering, audited a completed project on Greenville County's SC–14, in District 3. The project widened a section of SC–14 from two lanes to three, with the center lane as a dedicated left-turn lane or a two-way left-turn lane.

The audit team first reviewed relevant data and documentation, including plans for the project, intersection crash and traffic volume data, and profiles (plans showing the vertical alignment of the road design), and also interviewed the District 3 construction engineer. Then the team drove the relevant section several times, stopping often to view areas of concern more closely, over the course of 1.5 hours. In the end, the team offered nine suggestions:

- At the Roper Mountain Road intersection, extend the paved shoulder on the radii in all four corners to cover areas being damaged by vehicles, especially trucks.
- Add more speed limit signs.
- Add delineator signs to concrete islands at one intersection, or remove the islands.
- Trim vegetation at the entrances to two subdivisions, where sight distances are poor.
- Trim tree limbs overhanging Roper Mountain Road eastbound to improve the signal head visibility.
- Address ponding in valley gutter sections at stations 198+00 to 199+25 on the east side and 191+00 west directly across from Spaulding Farm.
- Consider more grinding or reconstruction at 150+75 and 156+50 because catch basins likely are not receiving water.
- Consider redressing and reseeding shoulders throughout the project except for curb-and-gutter sections.
- Address excessive voids in the road surface.

"Overall, the project is constructed satisfactorily," the auditors wrote in their report. "No major design issues were noted. Provided the items above are addressed, this portion of SC–14 should provide for many years of safe and efficient travel."

Important to note is that despite the project being essentially sound, the RSA was able to turn up "marginal" modifications that saved lives and millions of dollars.

City of Tucson

The city of Tucson developed HAWK signals, such as the one shown here, specifically to aid pedestrians at crosswalks. An RSA recommended changes to the device and roadway environment around it that improved safety for pedestrians even more.

emergency response and government access routes, matching road design with speed, and considering context sensitive gateways.

Collier County, FL. In 2002, the FHWA team conducted an RSA on a project at the conceptual stage, which involved widening a section of Immokalee Road from two lanes to four. To accommodate current and forecast demands, Collier County now is considering additional widening to six lanes.

The RSA suggestions included improved access management features, right-turn acceleration lanes, devices and designs to prevent wrong-way movements, signal operation and median treatments to prevent midblock crossings, pedestrian countdown signals, a continuous pedestrian network, improvements to existing bicycle facilities, avoidance of fixed objects and sight-line obstructions in the median, angled left-turn lanes in wide medians, redundant signal displays and/or double red displays for left-turn signals, backplates with reflective borders on traffic signals, coordinated traffic signal progressions, and considerations of the needs of older drivers. Collier County has since decided to establish a program of regular RSAs and has consultants on retainer for future projects.

City of Tucson, AZ. FHWA's team conducted an RSA of a corridor where the HAWK (*H*igh-intensity *A*ctivated cross*W*al*K*) pedestrian crossing device had been installed. The HAWK is a type of traffic control beacon developed by Tucson for marked pedestrian crosswalks and currently is approved for experimentation under the *Manual on Uniform Traffic Control Devices* (MUTCD) and is under consideration for inclusion in the next edition of the MUTCD. The RSA suggested placing "no passing" lines in crosswalk approaches, activating the dual red lights simultaneously, using split phasing for median-divided streets, using reflective-border backplates, lowering the walking speed to 1.1 meters (3.5 feet) per second for all crossings (not just school crossings), and making connections to pedestrian facilities.

Wisconsin. In December 2003, an RSA on the Marquette Interchange (I–43, I–94, and I–794) was the first done on a megaproject in the United States. The RSA team was limited in what it could feasibly review given the volume of documentation associated with the $800 million project, its advanced design stage, the completion of the public involvement process, and the limited time available for the RSA.

Nevertheless, the team identified six categories of safety issues, ranging from location-specific to general project conditions, for WisDOT to consider for improving the new design. Suggestions included revising advance signage for a specific ramp, adding flexible delineators or lengthening concrete barriers to reduce the chance of inappropriate exiting maneuvers, improving pavement markings at various locations, conducting additional microsimulation modeling, signalizing and coordinating ramp intersection traffic movements, restricting certain movements, improving pedestrian accommodation at several intersections, providing higher barrier heights on several ramps, placing ramp speed limit advisory signs, adding "gawk screens" to avoid motorists being distracted at work zones, considering some street closures and turning restrictions during construction, and changing construction staging to reduce traffic on certain streets.

Pedestrian RSAs

Nearly all transportation projects have some degree of pedestrian activity; even roadways in remote areas may serve walkers from time to time. Walkers may not be explicitly or adequately considered in some transportation projects, however, due to a lack of training for traffic engineers on meeting pedestrian safety needs. This lack of training factor makes it critical that pedestrian safety be incorporated into the RSA process.

Accordingly, FHWA is developing a report, *Pedestrian Road Safety Audit Guidelines,* and a companion "Pedestrian Road Safety Audit Prompt List" that can be used together during the RSA process. These resources will contain detailed information on issues that audit teams should address. Delivery is expected in early 2007.

Instead of checks to verify that minimum standards are being met, the prompt list will guide auditors to look for potential issues, such as those that are not addressed by vehicle-oriented standards or those that can arise from minimum or inappropriate standards.

The guidelines will parallel the prompt list and will provide a more detailed explanation of potential issues. Photographs of good and poor designs will provide examples.

Instead of focusing exclusively on pedestrian needs and issues, the guidelines and prompt list will look at how pedestrians and other modes interact. For example, can a driver see pedestrians waiting or attempting to cross? Are left-turning drivers so focused on finding gaps in conflicting traffic that they may neglect to look for crossing pedestrians? Do larger corner radii, which make it easier to turn a corner without slowing down, encourage higher speeds?

RSA Resources

FHWA offers two RSA training courses for transportation professionals in State and local transportation agencies and tribal governments. The first is a 2-day course available through

During an RSA training exercise, a team performs an onsite inspection at an intersection in Tampa, FL.

the National Highway Institute (NHI), called Road Safety Audits and Road Safety Audit Reviews, FHWA-NHI-380069. Information on course scheduling can be found online at www.nhi.fhwa.dot.gov. The second course, RSA for Locals, is geared toward local agencies, tribal governments, and Federal land management agencies. This course is free and can be presented in 1-day or 2-day formats, with the longer course including information on low-cost safety improvements and a field exercise RSA. (For more information about the RSA for Locals course, contact the author of this article.)

Because technical or procedural questions often arise before and during an RSA, FHWA has established the RSA Peer-to-Peer (P2P) program to provide assistance, at no cost, to agencies either considering the use of or actually conducting RSAs. A State, local, or tribal agency may request assistance either by e-mail at SafetyP2P@fhwa.dot.gov or by calling the toll-free number 1–866–P2P–FHWA and talking with the FHWA-sponsored P2P coordinator. The coordinator will match the agency with a knowledgeable transportation professional. The matched peer then will contact the agency to work out the details of the assistance, which may include a site visit as needed.

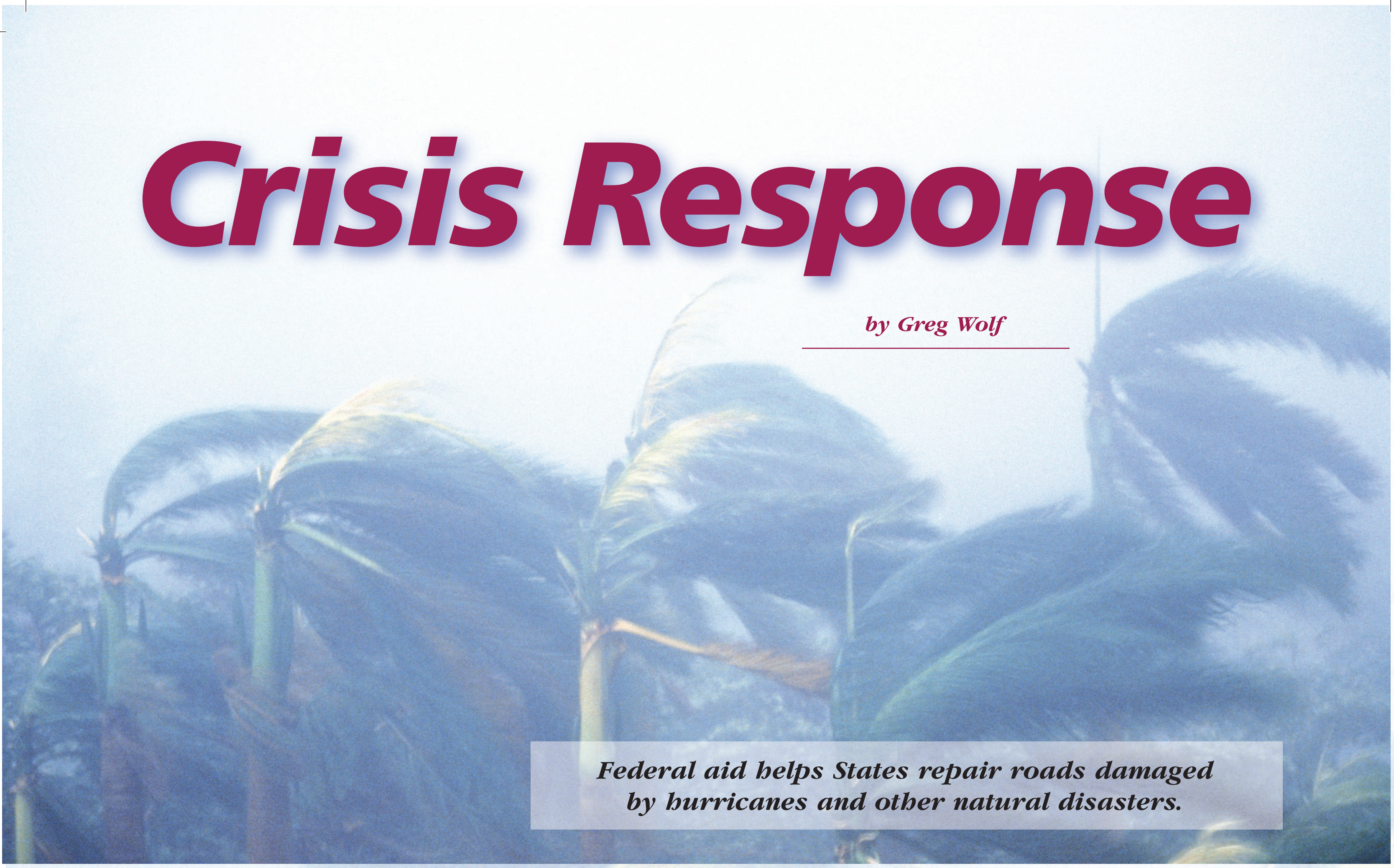
RSAs can have an important impact on the safety of the Nation's roads and intersections. To receive assistance in implementing the RSA process, contact the local FHWA division office or contact the author of this article directly.

Louisa Ward is the RSA program manager for FHWA's Office of Safety. She has worked in various roles in FHWA for the last 7 years. She previously worked for the Institute of Transportation Engineers as its technical program manager for traffic engineering and safety, and as the assistant traffic engineer for the city of Kettering, OH. Ward received her bachelor's degree in civil engineering from the University of Dayton.

For more information, or to schedule the RSA for Locals course, contact Louisa Ward at 202-366-2218 or louisa.ward@fhwa.dot.gov. For Resource Center technical assistance on RSAs, contact Craig Allred at 720-963-3236 or craig.allred@fhwa.dot.gov. To contact the RSA P2P program, call 866-P2P-FHWA or e-mail SafetyP2P@fhwa.dot.gov. For pedestrian RSAs, contact Gabriel Rousseau at 202-366-8044 or gabriel.rousseau@dot.gov.

Crisis Response

by Greg Wolf



Federal aid helps States repair roads damaged by hurricanes and other natural disasters.

Responding mainly to hurricane damage in the Southeast and winter storms in the West, the Federal Highway Administration (FHWA) is disbursing $686 million to help cover the cost of road repairs in 31 States and territories.

"Our priority after a natural disaster or emergency is repairing the transportation network so local communities can rebuild, businesses can reopen, and people can resume their lives," said Federal Highway Administrator J. Richard Capka when he announced the Federal aid on July 31, 2006.

The aid is being channeled through FHWA's emergency relief (ER) program and was allocated through the Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Hurricane Recovery, 2006. President George W. Bush signed the bill June 15, 2006.

(Above) Among natural disasters that have affected U.S. roadways in recent years, hurricanes such as the one shown here eroded pavement and blew down signs, costing southeastern States more than $100 million in highway repairs.

The ER Program

The ER program reimburses States for 100 percent of costs incurred during the first 180 days after a natural disaster to restore essential transportation services, protect lives and property, or prevent further damage. It also applies to temporary repairs and removal of debris on Federal-aid highways. For permanent repairs, Federal funds reimburse States at 80 percent for the National Highway System and 90 percent for the Eisenhower Interstate System.

Congress authorized the ER program in 1958 to help repair or rebuild Federal-aid highways and roads on Federal lands damaged by natural disasters or catastrophic failures from external causes. To be eligible under the disaster provision, highway damage must be severe, occur over a wide area, and result in unusually high expenses to the highway agency, such as those caused by floods, hurricanes, earthquakes, tornadoes, tidal waves, severe storms, and landslides.

Also, each reimbursable event must be declared a disaster by the State's Governor. The damaged roadway must be a Federal-aid highway, defined by functional classification as highways other than rural minor collectors and local roads. (Non-Federal-aid highways may be eligible for assistance from the Federal Emergency Management Agency.)

Generally, elements of the damaged highway eligible for ER funds include pavement, shoulders, slopes and embankments, guardrails, signs and traffic control devices, bridges, culverts, bike and pedestrian paths, fencing, and retaining walls. Other eligible items include engineering and right-of-way costs, debris removal, transportation system management strategies, administrative expenses, and equipment rental expenses. The following States received aid from recent disasters.

West Coast Winter Storms

California received nearly half—$309.1 million—of FHWA's total disbursement, most of it ($296.2 million) reflecting winter storms. In December 2002, heavy rain and flooding washed out portions of 9 highways in 15 counties. In December 2004, a series of powerful storms dropped record rainfall on southern California, causing flooding, mudslides, debris accumulation, and roadway washouts in 8 counties. (The remainder of California's allotment was related to summer flash flooding near Death Valley National Park and the San Simeon Earthquake in San Luis Obispo County.)

Oregon was affected by heavy rains in December 2005, resulting in flooding and landslides that seriously damaged Federal-aid highways in 24 counties. FHWA awarded the State $38 million for eligible highway repairs associated with the disaster.

To the north, Washington State also was pummeled by winter storms. Beginning December 19, 2005, and lasting 6 weeks, a series of fronts brought heavy rain, high winds, and flooding, damaging roads statewide. The Governor declared a state of emergency for 39 counties. In December 2004, 4 days of rain and wind had damaged roads in Jefferson County; in October 2003, a week of rain and wind flooded highways and bridges in 12 counties; and in September 2005, a rain-induced rockslide damaged I–90 in King County. The State was reimbursed $19.4 million for the disasters.

In addition to the West Coast, Hawaii received $11.5 million for floods experienced in March 2006. Rain fell throughout the State all month, most dramatically triggering failure of the Ka Loko Reservoir, which substantially damaged the Kuhio Highway.

Hurricanes

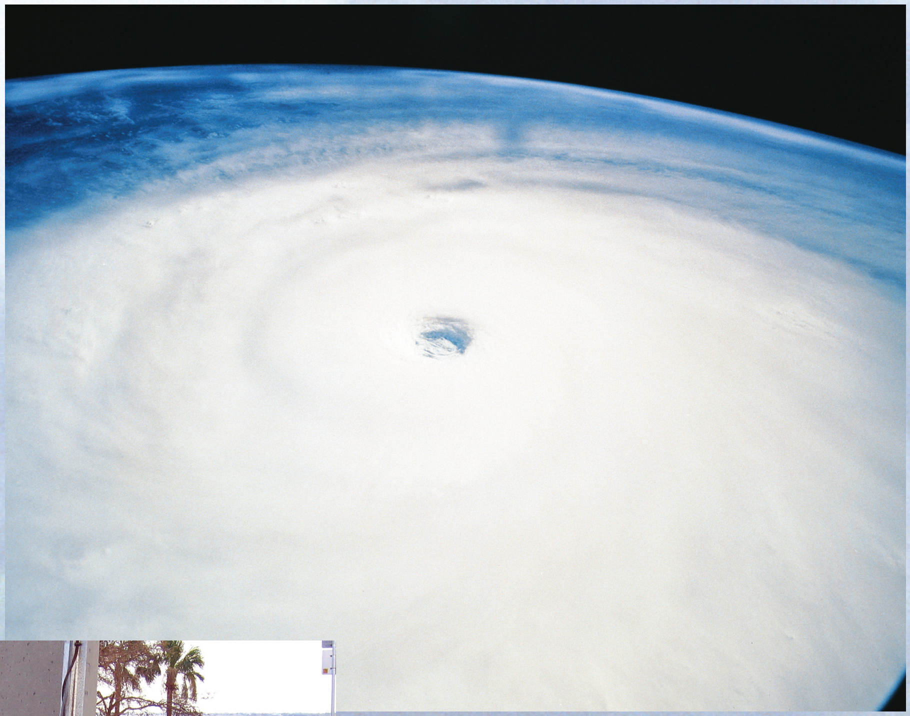
Nearly $130 million of the emergency spending bill covered damages from five hurricanes and three similar storms. Most expensive by far was Hurricane Dennis, which struck the Florida Panhandle on July 10, 2005. Dennis was the first hurricane of the 2005 Atlantic season, reaching the Saffir-Simpson Hurricane Scale Category 4 status at its peak. It arrived in Florida with sustained winds of 159 kilometers per hour (kph) (99 miles per hour [mph]) and gusts up to 195 kph (121 mph). Dennis damaged areas between Tallahassee and Pensacola, including U.S. 98, which runs along the coast for more than 322 kilometers (200 miles). Florida received $118.5 million from FHWA as reimbursement.

"It's great for the State of Florida that we received this help," says James Rodgers, District 3 director of transportation operations for the Florida Department of Transportation. Fast-growing Florida already is $50 billion to $70 billion behind in infrastructure construction and can scarcely afford expensive setbacks, he says.

"Every hurricane is unique, and Dennis was different in that it did most of its damage 150 miles [242 kilometers] away from its direct-hit site, off in Franklin County," Rodgers explains. In Franklin County, the State will oversee about $90 million in recovery work compared to $75 million of construction work in the remainder of Florida.

Alabama was damaged by Hurricane Ivan, which came ashore at Gulf Shores early on September 16, 2004. A Category 3 storm, Ivan's peak winds topped 201 kph (125 mph) and produced a 4.9-meter (16-foot) storm surge. Most of the highway damage came in the form of downed trees, landslides from heavy rainfall, and trees drifting into bridges. The storm surge caused roadway washouts in coastal Baldwin County and Mobile County. Alabama had already received ER funds from FHWA for Hurricane Ivan, but the emergency spending bill provided another $5.2 million for additional needs.

Hurricane Isabel struck the beaches of North Carolina on September 18, 2003, causing widespread flooding and damage to Federal-aid highways. It brought winds up to 161 kph (100 mph) and overwash to the Outer Banks that destroyed homes



(Above) Established 50 years ago, the ER program responds to damage to the Nation's roadways from natural disasters such as the hurricane seen here from space.

(Left) The ER program reimburses States for disaster-related damage to roadways, defined to include signs, traffic control devices, guardrails, and other elements.

The storm surge from Hurricane Dennis in 2005 washed out this stretch of U.S. 98 along Florida's Panhandle coast.

and parts of the main highway, NC–12. The $5.0 million provided by FHWA responded to a supplemental request to cover repairs of the Herbert C. Bonner Bridge.

Hurricane Ophelia also primarily affected North Carolina, making landfall on September 14, 2005, but heading back out to sea the following day. Transportation-related damage came from large-scale timber debris on Federal-aid roads, countywide sign and signal destruction, drainage pipe and pavement washouts, and damage to ferry routes and ports. The State received $1.2 million in reimbursement.

The fifth hurricane was Floyd, now 7 years past. New York State received $245,000 to supplement earlier aid. In September 1999, Floyd brought heavy rain and high winds, leaving debris and otherwise damaging roads and bridges in much of the State. Federal-aid highways were affected in 16 counties. (New York received $11.8 million, mostly for flood damage not related to hurricanes.)

The emergency appropriations also covered damage in South Carolina from Tropical Storm Gaston in August 2004, in American Samoa from Tropical Cyclone Olaf in February 2005, and in the Northern Mariana Islands from Typhoon Chaba in August 2004. The combined aid for these three storms was about $2.7 million.

Of course, the worst hurricane in recent memory was Katrina, and FHWA addressed it following passage of another spending bill, the Department of Defense, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic Influenza Act, 2006, signed by President George W. Bush on December 30, 2005. In total, nearly $2.8 billion in ER funds were provided to the gulf coast region to address Federal-aid highway damage related to Katrina (and to lesser extents to Hurricanes Rita and Wilma). Louisiana received $1.2 billion, Mississippi $1.0 billion, and Alabama, Florida, and Texas divided the remainder.

New England Flooding

The appropriations also included about $24.2 million to help cover damage suffered in New England from unprecedented autumn rainfall. The downpours began October 7, 2005, and continued for 11 days. By the time the rains ended, Federal-aid roadways were damaged throughout the States of Connecticut, Massachusetts, New Hampshire, and Rhode Island.

Worst hit was New Hampshire, where severe rain and flooding occurred in every county. The Governor declared a State of Emergency on October 9, 2005, after 28 centimeters (11 inches) of rain had fallen in 24 hours in portions of the State. New Hampshire received $17.9 million in aid from FHWA. Least affected was Connecticut, which received $735,000.

Massachusetts received $3.9 million for Federal-aid roadways damaged in six counties. Rhode Island received $1.7 million to assist with flood damage recovery after a week of rain, and the Governor on October 17, 2005, declared a disaster. Road damage encompassed both multilane principal arterials and other facilities. I–95 sustained heavy damage, with severe erosion of embankment slopes and undermining of pavement and guardrails.

Other Items

About $22 million was provided to cover flood damage in the interior West. In normally arid Nevada, a series of storms beginning December 24, 2004, and not ending until January 14, 2005, brought heavy rainfall to higher elevations. This followed early winter snows, and extreme runoff and flooding occurred. Nevada received $16.9 million in reimbursement from FHWA. Southwestern Utah suffered severe storms and flooding that destroyed or damaged eight bridges and 16.1 kilometers (10 miles) of roadway. The State received $5.1 million in aid.

Montana received $15 million to compensate it for two rockslides. In May 2005, heavy rain and snowmelt caused flooding and slides along the Beartooth Highway, which provides access to Yellowstone National Park in Wyoming. In February 2004, a rockslide damaged U.S. 93 along the Montana-Idaho border.

And in the Midwest, Ohio was reimbursed $51.5 million for winter storm damage beginning in December 2004. After 1 week of rain, the Governor's Office declared a disaster that included 20 counties. On January 13, the Governor amended the declaration to include 39 more counties, and in April he declared another 3 counties as disaster areas.

Greg Wolf is the ER program engineer with the FHWA Office of Program Administration in Washington, DC, a post he has held since October 2003. He provides technical assistance and guidance on ER program issues to FHWA division office personnel as well as State and local partners nationwide. He holds a bachelor's degree in civil engineering from the University of Maryland.

For more information, contact Greg Wolf at 202-366-4655 or greg.wolf@dot.gov.

A new public-private partnership promotes environmental stewardship while fostering innovative streamlining and market-based approaches to meeting transportation needs.

by Marlys Osterhues

On the Way to Greener Highways

When building and maintaining a safe and efficient surface transportation system, impacts on the natural and cultural environments are inevitable. But Federal, State, and local highway agencies are taking steps to integrate environmental sensitivity into their day-to-day activities, which range from recycling old pavements and protecting watersheds during construction to involving community members and business leaders in the transportation decisionmaking process.

In 2002, the Federal Highway Administration (FHWA) designated environmental stewardship and streamlining as one of its three "vital few" goals, along with safety and congestion mitigation. Subsequently, FHWA made substantial investments in improving the quality and efficiency of environmental decisionmaking through initiatives such as context sensitive solutions (CSS), the *Eco-Logical* approach, the Exemplary Ecosystem Initiatives program, the recently announced Human Environment Initiatives program, and efforts to link planning and the environment.

(Above) Centerton Nursery created this unusual "green highway" display at the Eastern Performance Trials at River Farm, Alexandria, VA, in September 2005. *Photo: American Horticultural Society.*

Building on this momentum, a new multidisciplinary partnership brings together the diverse initiatives and activities that contribute to the "greening" of U.S. highways. The Green Highways Partnership (Green Highways) is a voluntary, collaborative effort aimed at fostering partnerships to improve upon natural, built, social, and environmental conditions, while addressing the functional requirements of transportation infrastructure. Green Highways provides State departments of transportation (DOTs) the opportunity to highlight the many good environmental practices already underway and encourages additional innovations.

FHWA is one of many partners that include Federal and State transportation and regulatory agencies, contractors, industry groups, trade associations, academic institutions, and nongovernmental organizations focused on highways and resource management issues. The partnership engages practitioners who represent an array of disciplines, including engineering, environment, law, safety, operations, maintenance, and real estate.

Green Highways grew out of efforts by the U.S. Environmental Protection Agency's (EPA) Region 3, which consists of the mid-Atlantic States of Delaware, the District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia. "The goal is to achieve transportation and environmental objectives so that both are 'better than before,'" says Hal Kassoff, senior vice president at Parsons Brinckerhoff, Inc., a consultant involved in the initiative.

Woven throughout the Green Highways concept are the critical drivers of integrated planning, market-based approaches, regulatory flexibility, and environmental streamlining. "Green Highways represents the next logical step in the evolution of FHWA and State DOT efforts in environmental streamlining and stewardship, building on recent investments over the last few years," says Shari Schaftlein, team leader for program and policy development at FHWA's

Setting the Stage for Green Highways

The Green Highways Partnership creates opportunities to unite a number of existing, complementary activities and efforts under a single comprehensive approach.

Context sensitive solutions (CSS). CSS is a collaborative, interdisciplinary approach that involves stakeholders in developing transportation facilities that complement their physical settings and preserve scenic, aesthetic, historic, and environmental resources while maintaining safety and mobility. See www.fhwa.dot.gov/csd.

Exemplary Ecosystem Initiatives. Through the Exemplary Ecosystem Initiatives program, FHWA recognizes best practices in environmental stewardship demonstrated at the State level. Since 2002, FHWA has highlighted more than 20 innovative and forward-thinking initiatives that employ ecosystem-based approaches. See www.fhwa.dot.gov/environment /ecosystems.

Planning and Environment Linkages. FHWA has hosted more than 20 workshops across the country to promote the linkages between planning and the National Environmental Policy Act. See http://environment.fhwa.dot.gov/integ/index.asp. Also, a planning work group, chaired by FHWA and established as part of Executive Order 13274, Environmental Stewardship and Transportation Infrastructure Project Reviews, aims to advance integrated planning by bringing together the necessary agencies and stakeholders early on. For more information on the executive order, visit www.fhwa.dot.gov/stewardshipeo/eo13274.htm.

Eco-Logical. To promote ecosystem approaches to transportation development, FHWA championed a multiagency effort to develop a nonprescriptive approach to making infrastructure more sensitive to wildlife and ecosystems through greater agency cooperative conservation. The effort culminated in May 2006 with release of the publication *Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects* (FHWA-HEP-06-011). See www.environment.fhwa.dot.gov/ecological/ecological.pdf. Also see *The Nature of Roadsides* (FHWA-EP-03-005), which describes an ecological approach to highway rights-of-way.

Geospatial Tools. Innovative technologies, such as geospatial tools, also contribute to ongoing collaborative efforts that facilitate greener highways. FHWA advocates use of geospatial tools and technologies to streamline consideration of environmental challenges in the development of transportation projects. In May 2006, for example, FHWA sponsored a mid-Atlantic peer exchange through the Transportation Research Board to gain support and develop a network of professionals involved with geospatial applications in transportation and environmental decisionmaking. See www.gis.fhwa.dot.gov.

Recycling. FHWA is encouraging an industrial byproducts exchange for recycling and reusing materials. For more information on FHWA's recycling efforts, visit www.fhwa.dot .gov/pavement/recycling/index.cfm.

Office of Project Development and Environmental Review.

Through a combination of networking events and opportunities, public-private partnerships, and a new Web site clearinghouse (www.greenhighways.org), Green Highways proponents are pushing the boundaries of traditional highway-building practices. "Whether one represents industry or agency, everyone involved welcomes the opportunity to advance to a more sustainable country and world," says Robb Jolly, senior vice president of market development for the American Concrete Pavement Association (ACPA).

Green Highways Forum

In June 2005, EPA's mid-Atlantic region hosted an executive planning charrette (technique for engaging multiple stakeholders in intense planning sessions) in Philadelphia, PA, to define and establish a vision for Green Highways. More than 50 senior-level executives from the public and private sectors participated. Several FHWA division administrators, division environmental staff, and other representatives attended the session.

The initial organizing efforts culminated with a Green Highways Forum, held November 8–10, 2005, in College Park, MD. The forum brought together, for the first time, several hundred Federal, State, and local transportation and environmental officials, as well as professionals from the private sector and trade associations. "The Green Highways Forum is a turning point toward the creation of goodwill relationships and partnerships for the advancement of transportation and the environment," said FHWA Associate Administrator for Planning, Environment, and Realty Cynthia J. Burbank, speaking at the event.

FHWA officials discussed with attendees the opportunities afforded by the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). A number of SAFETEA-LU provisions advance concepts and strategies relevant to green highways. For example, the law contains a new responsibility on transportation planning for States and metropolitan planning organizations (MPOs) to look explicitly at environmental mitigation needs associated with implementing transportation plans or transportation improvement programs. Another new element is the requirement to compare transportation plans with environmental plans, inventories, and maps.

SAFETEA-LU also modifies the environmental review process for projects requiring environmental impact statements. The law calls for early coordination and requires that agencies and the public be given opportunities for involvement in defining the purpose and needs as well as the range of alternatives. Specifically, SAFETEA-LU adds a new category of "participating agencies" to enable State, local, and tribal agencies to play more formal roles in the environmental review process.

The new law also encourages research and technology transfer by establishing a new national cooperative research program for environmental and planning research. Cooperative research efforts put a premium on partnerships such as those formed around Green Highways.

Developing a Roadmap

As a followup to the forum, more than 40 representatives from the public and private sectors attended a retreat in St. Michaels, MD, in March 2006. The purpose was to frame the future of Green Highways and to refine the roadmap for the partnership.

The group divided into three theme-focused teams to translate the Green Highways vision into pilot projects with measurable outcomes. Attendees identified the following three focus areas that offer the greatest potential to demonstrate Green Highways concepts:

- Watershed-driven stormwater management (plans, designs, structural products, and practices)
- Recycling and reuse (industrial byproducts and use of recycled materials)

- Conservation and ecosystem management (principles and practices)

"These areas are ripe for focus because of advancements in environmental science and technology," says ACPA's Jolly.

Raja Veeramachaneni, director of the Office of Planning and Preliminary Engineering at the Maryland State Highway Administration (SHA), adds that "to achieve successful outcomes, significant collaboration is needed to piece together aspects of a wide variety of laws, regulations, procedures, procurement methods, and specification requirements. A functioning partnership is essential to develop timely solutions when obstacles arise."

A current focus of Green Highways is to implement pilot projects that demonstrate the concepts visibly and tangibly in the mid-Atlantic region. "Pilot projects will inform and inspire the implementation of practices and actions that are innovative, efficient, cost effective, and environmentally sound," says Veeramachaneni. "The anticipated outcome of the pilots is to demonstrate sustainable solutions and provide for market-based incentives. Pilots also will serve to improve partnerships and research efforts. Green Highways serves as an opportunity to translate good ideas into practical realities."

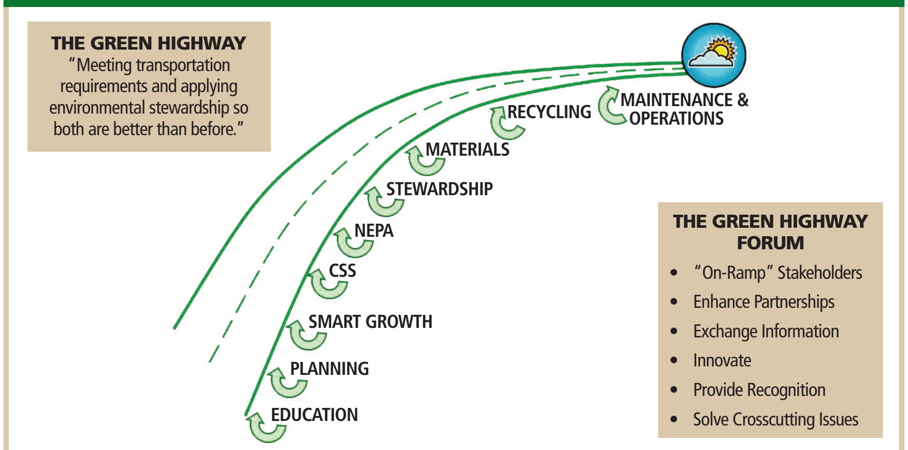
Stormwater Management

The team focusing on stormwater management is pursuing the following activities:

- Promoting collaboration between diverse public and private stakeholders with the mutual goal of supporting the sustainable use of natural resources and developing coordinated solutions
- Demonstrating effective stormwater-related best management practices (BMPs) for transportation projects on a watershed basis
- Assessing the flexibility of the regulatory and policy framework in the Clean Water Act
- Identifying case studies, with the goal of showcasing up to 10 innovative stormwater demonstration projects in the District of Columbia, Maryland, and Pennsylvania

Stormwater management innovations are underway throughout the mid-Atlantic region. Urbanized areas are particularly challenging. In 2004, in Washington, DC, the District Department of Transportation (DDOT) installed a biocell for stormwater management at Benning Road Bridge. A biocell is composed of natural materials such as mulch, soil mix, and various types of vegetation. Rather than require an engineered structure like a weir or drainage pit, a biocell acts like a filtration trench, where the soil or natural drainage materials filter the water. A biocell can remove up to 90 percent of the suspended solids from stormwater. This project represented the first use of low-impact stormwater management technology by the District Government.

The "On-Ramps" to a Green Highway



Produced by one of the stakeholders in the Green Highways Partnership, this graphic illustrates how existing environmental initiatives and highway activities feed into the Green Highways concept. *Source: Andy Fekete, RBA Group.*

Green Highways

- Provides an opportunity to highlight effective practices.
- Advances cost-effective, environmental streamlining opportunities.
- Integrates planning and market-based opportunities.
- Encourages innovations.
- Explores regulatory flexibility.
- Provides networking opportunities.
- Facilitates pilot projects.
- Provides an umbrella for transportation and green-infrastructure initiatives.

To illustrate commitment to supporting innovations in stormwater management, FHWA and EPA cofunded a $1 million Anacostia River Urban Watershed Partnership Grant. The grant, announced on Earth Day 2006, set up a competition for pilot projects designed to protect and restore urban water resources through a holistic watershed approach to managing water quality.

Recycling and Reuse

The recycling and reuse team is focusing on efforts in a number of areas. First, team members are identifying existing regulations and specifications. The team then will develop State performance standards and specifications for voluntary use of recycled materials in highways. The team also is collecting and disseminating information to increase use of recycled products and developing opportunities to exchange best practices. In addition, the team will produce a toolkit to provide technical information and guidance to help DOTs overcome hurdles.

Another priority is to identify State DOT projects that optimize the beneficial reuse of industrial byproducts. To date, Maryland, Pennsylvania, Virginia, and West Virginia have been targeted for pilot projects to showcase beneficial reuses in their States.

As each State offers ongoing stewardship examples, Green Highways will help increase the visibility of these activities and increase their use on more projects. For example, the Pennsylvania Department of Transportation constructed the Tarrtown Bridge using shredded tires as lightweight embankment fill on two bridge approaches. The project incorporated approximately

District (of Columbia) DOT

This lowland area is a bioretention facility on Benning Road in Washington, DC, designed to manage stormwater.

780,000 scrap tires, thereby easing the load on landfills.

In West Virginia, the DOT is using recycled blast furnace slag as the aggregate of choice in the western part of the State for the majority of the asphalt surface course pavements. The effort results in a safer pavement due to the aggregate's nonpolishing properties (higher friction number). According to Jason Harrington, an asphalt pavement engineer with FHWA, with an open-graded friction in course aggregate like slag, the roadway does not experience as much spray or misting during rain, offering better visibility and much less hydroplaning. Further, recycling blast furnace slag, which is available locally, offers an economic advantage compared with using virgin limestone aggregate.

"Although the 'coarseness' in slag increases friction, which is highly desirable, the size of the aggregates are larger, which contributes to a slight increase in noise levels. When noise is a concern, the use of smaller aggregate sizes [0/6 mm or 0/10 mm] is recommended," says Chris Corbisier, FHWA highway traffic noise specialist.

Conservation and Ecosystem Management

The conservation and ecosystem management team focuses on how to bring advances in mapping and data management together with various initiatives in conservation and ecosystem management to achieve greener highways. The data and regulatory managers are working to gain agreement on how to develop a set of tailored, core datasets and maps that can be integrated at both the transportation project and planning levels. The maps will facilitate information sharing at the Federal, State, MPO, and local levels, and will facilitate the integration of conservation and ecosystem management practices into land-use planning. Priority areas for conservation will emerge from the development of a regional ecosystem framework.

Green Highways will build on the concept of "green infrastructure," a national effort aimed at better integrating the built and natural environments through greater understanding of the location and health of various habitats. Green infrastructure relates to a strategic approach to conservation that promotes planning, protection, restoration, and long-term management that is proactive, systematic, holistic, multifunctional, and science-based. "Green infrastructure is not a program or a regulatory-driven initiative; rather, it is an approach that provides both predictability and certainty to transportation professionals and the conservation community," says Kris Hoellen, director of The Conservation Fund's Conservation Leadership Network.

"Green Highways provides the umbrella through which to coordinate transportation processes with green infrastructure and other environmental regulatory and nonregulatory actions in an integrated fashion, including opportunities for regulatory incentives and innovative and flexible stormwater and water quality management," adds Dominique Lueckenhoff, associate director of the Water Protection Division, Office of State and Watershed Partnerships, EPA Region 3.

FHWA is developing a solicitation for research projects that support and further the conservation and ecosystem management principles embodied in Green Highways and related efforts such as CSS, integrated planning, and the ecosystem-based approach outlined in the recent FHWA publication *Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects* (FHWA-HEP-06-011).

Existing successes in innovative conservation and ecosystem efforts include the Blue Ball Properties project in Delaware. The Delaware Department of Transportation partnered with two other State agencies and the local community to develop a master plan for the area. Using an environmental stewardship approach, the mitigation package includes seeding several large areas as meadow; restoring a stream; creating a wetland; developing a regional stormwater management system that includes bioswales, detention basins, and meadow depressions; and replanting with native species. (For more on the Blue Ball Properties project, see the May/June 2003 PUBLIC ROADS article, *A Benchmark for Livable Progress* by Robert B. King.)

The Virginia Department of Transportation (VDOT) has demonstrated

The Green Highways Partnership's conservation and ecosystem team focuses on such best practices as restoration of streams like this one in Prince George's County, MD. The goal here was to stabilize eroding stream banks, provide grade controls, and increase habitat features as mitigation for construction of an access road near the Washington Redskins' football stadium. *Photo: Maryland SHA.*

a commitment to conservation and ecosystem management through technology innovations. VDOT's Comprehensive Environmental Data and Reporting (CEDAR) system provides environmental staff statewide with a one-stop location for project documents, images, and forms that are environmentally related. CEDAR documents environmental decisions, facilitates improved project management, streamlines interagency coordination, and strengthens the communication of environmental commitments.

Maryland's Green Highway

In addition to the pilot efforts under development within each theme area, the partnership is looking to apply Green Highways concepts in a more comprehensive manner. Toward that goal, the Maryland SHA recently volunteered to apply an environmental stewardship approach to a transportation improvement project by implementing the following key actions:

- Application of environmental stewardship principles in the development of alternatives retained for detailed study
- Full integration of the regulatory requirements for avoiding and minimizing direct impacts on resources through planning and design measures and modifications
- Incorporation of state-of-the-art features, design techniques, and BMPs
- Evaluation of overall resource conditions and identification of priority stewardship needs in consultation with project partners and public stakeholders using a watershed framework for environmental management
- Design and implementation of plans, strategies, and actions—beyond those associated with compensatory mitigation—that seek to improve the overall natural, community, and cultural environments
- Identification of a preferred alternative that furthers the project purpose, satisfies the project needs, and balances and minimizes direct, indirect, and cumulative impacts on natural, community, and cultural resources

In keeping with the collaborative nature of Green Highways, SHA is planning a design charrette to investigate potential green approaches, technologies, and actions. "This project will provide an opportunity to integrate all of the principles and concepts of Green Highways into a single project and has the potential to serve as a model for other projects in the mid-Atlantic and across the country," says SHA's Veeramachaneni.

Green Highways Network

The Green Highways Partnership also is forming a communications network that is being maintained through a Web site (www.greenhighways.org), regularly scheduled leadership meetings, and press events. Among its diverse functions, the network will craft a Green Highways awards and recognition program; develop, implement, and manage the pilot programs; identify and seek funding mechanisms; and act as a conduit to environmental entities at Federal, State, and local government levels, academia, nongovernmental organizations, and trade and industry groups.

The network will coordinate outreach with organizations such as AASHTO, American Road & Transportation Builders Association, and the consulting community.

According to Lueckenhoff, from EPA Region 3, the Green Highways Web site serves as a tool to consolidate resources, support effective communication and networking, streamline information sharing, and facilitate technology transfer. "The site will be the information 'nerve center' for all activities related to Green Highways," she says.

In addition to the Web site, the partnership is pursuing other outreach activities across the mid-Atlantic to spread the word about Green Highways. Proponents are meeting with State DOT executives across the region to explain the goals and objectives of the partnership and assess interest and opportunities within the theme areas. Further, the Transportation Research Board's (TRB) ADC10 Committee on environmental analysis in transportation is planning a Green Highways workshop for the annual TRB conference in Washington, DC, in January 2007.

A bulldozer is leveling a pile of shredded tires that are being reused as lightweight fill for a bridge abutment and slope. Recycling is one aspect of creating greener highways.

Looking Forward

Building on innovative programs and approaches spawned from transportation and resource agencies, Green Highways will make it easier for DOTs to integrate common-sense, economically feasible solutions into their day-to-day work in planning, building, and maintaining the Nation's surface transportation system. Further, the initiative will provide opportunities to evaluate and streamline business practices.

"Partnerships like Green Highways are vital to the transportation community and can help facilitate the timely delivery of a quality transportation program," says Administrator Neil Pedersen of the Maryland SHA. "The ultimate goal of Green Highways is to develop self-sustaining, public-private and public-public partnerships."

Marlys Osterhues is an environmental protection specialist with the FHWA Office of Project Development and Environmental Review. She is responsible for advancing key environmental streamlining initiatives and providing NEPA guidance to FHWA division offices in New England and the mid-Atlantic.

For more information, contact FHWA's Marlys Osterhues at 202-366-2052, marlys.osterhues@fhwa.dot.gov, or EPA Region 3's Denise Rigney at 215-814-2726, rigney.denise@epa.gov. For a list of FHWA division office and EPA regional contacts, see www.greenhighways.org.

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

National Initiative to Tackle Congestion Launched

In May 2006, then-Secretary of Transportation Norman Y. Mineta announced a national initiative to tackle highway, freight, and aviation congestion. During remarks to the National Retail Federation, Mineta said that "congestion kills time, wastes fuel, and costs money." He noted that the United States loses an estimated $200 billion per year due to freight bottlenecks and delayed deliveries. In addition, consumers lose 3.7 billion hours and 2.3 billion gallons of fuel sitting in traffic.

The new initiative, the National Strategy to Reduce Congestion on America's Transportation Network, provides a blueprint for Federal, State, and local officials to tackle congestion, Mineta said. He noted that over the coming months, USDOT will focus its resources, funding, staff, and technology on reducing traffic jams, relieving freight bottlenecks, and cutting flight delays. The initiative will seek Urban Partnership Agreements with communities willing to demonstrate new congestion relief strategies and will encourage States to pass legislation giving the private sector a broader opportunity to invest in transportation. The goals of the initiative are more widespread deployment of new operational technologies and practices that end traffic tieups, designation of new interstate "corridors of the future," reduced port and border congestion, and expansion of aviation capacity.

"The bottom line is that every person and every business in America has a vested interest in reducing congestion," Mineta said. "We don't have to let traffic delays put our lives on hold any longer."

To download a copy of the plan, go to http://isddc.dot.gov/OLPFiles/OST/012988.pdf. The Secretary's remarks can be found at www.dot.gov/affairs/minetasp051606.htm.

U.S. Helps Iraq Build Roads and Bridges

Acting U.S. Secretary of Transportation Maria Cino and Iraqi Minister for Construction and Housing Beyan I. Dezei made history August 4, 2006, by signing the first memorandum of cooperation (MOC) between the Federal Highway Administration (FHWA) and the Republic of Iraq.

The MOC will serve as the umbrella agreement under which both nations will engage officially in the exchange of transportation technology, and it will reaffirm the commitment of the United States to provide technical assistance to Iraqi roadbuilders.

The partnership will include the development of a Technology Transfer Center (TTC) in Baghdad and an engineering training program for Iraqi engineers in the United States. Through its University Transportation

Then-Acting U.S. Secretary of Transportation Maria Cino and Iraqi Minister for Construction and Housing Beyan I. Dezei sign the MOC between FHWA and the Republic of Iraq. The MOC will facilitate the possible development of a Technology Transfer Center and facilitate information sharing activities to meet the needs of the Iraqi highway transportation community. *Photo: Ben Mitchell, USDOT photographer.*

Centers and TTCs around the world, FHWA's National Highway Institute has developed an extensive roadbuilding training network. Lessons learned by international experts working in different climates, with different techniques and materials, will help to expand the knowledge base available to all road engineers.

The new U.S.-Iraq partnership will help motorists around the world by capitalizing on the insights gained by U.S. engineers in repairing road and bridge damage caused by natural disasters such as Hurricanes Katrina and Rita. Similarly, lessons learned from engineers internationally about road damage, repair and maintenance, sign placement, and lane width help U.S. transportation officials ensure the safety of motorists.

"We have long been partners with the Iraqi people in their transportation projects," says FHWA Administrator J. Richard Capka. "This memorandum of cooperation formalizes our relationship and will ensure that the highway programs of our two countries reap the benefits."

This year, Minister Dezei was in the United States for a whirlwind tour that included a visit to Washington, DC, to meet with FHWA officials, and to St. Petersburg, FL, where she participated in the Second International Symposium on Transportation Technology Transfer.

In 2004, FHWA hosted Iraqi officials interested in starting a technology exchange center in their country. Iraqi engineers also visited the United States in 2005 to work with FHWA's Federal Lands Highway Division and to receive on-the-job training on GEOPAK®, a civil engineering and transportation software technology.

Edward Rodriguez, FHWA

Public Information and Information Exchange

HSRC Receives $1.6 Million for National Bicycle, Pedestrian Clearinghouse

The University of North Carolina Highway Safety Research Center (HSRC) recently received $1.6 million for the renewal of the National Bicycle and Pedestrian Clearinghouse, a nationwide source of pedestrian and bicycle information and technical assistance.

Included in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, the clearinghouse is funded by FHWA for 2 base years, with

The National Bicycle and Pedestrian Clearinghouse has coordinated, both nationally and internationally, International Walk to School activities such as this one, where children are walking to Auburn Elementary School in California. *Photo: International Walk to School.*

an option for an additional 21 months. HSRC has operated the clearinghouse for the past 6 years, disseminating information and technical assistance in the areas of health and safety, access and mobility, engineering, education, advocacy, and enforcement.

With the new funding, the clearinghouse will continue promoting bicycling and walking as transportation options, using innovative approaches such as downloadable presentations and searchable databases, and responding to the needs of the clearinghouse's audiences. The clearinghouse also will analyze and evaluate bicycle and pedestrian programs, as well as develop core studies and best practices reports.

The clearinghouse is available for use by transportation planners, engineers, educators, enforcement officers, advocates, the health community, and citizens who have an interest in pedestrian and bicycle issues. Multiple interactive and technical tools are available for practitioners to input their local concerns and obtain tailored guidance. The clearinghouse's Web site, www.pedbikeinfo.org, received an award in 2006 for best planning, design, and development from Planetizen, a planning and development network.

For more information, contact Katy Jones at HSRC at 919–843–7007 or jones@hsrc.unc.edu.

HSRC

Personnel

Capka Appointed FHWA Administrator

Former Acting Administrator J. Richard Capka was officially sworn in as the 16th FHWA Administrator on May 31, 2006. On June 12, he wrote to FHWA staff: "Though we have much for which to be proud, it is clear that we still have much in front of us, and much is dependent upon our ability to deliver. . . . Technology and innovation are advancing at breakneck paces, and we need to be able to take full advantage of what they have to offer. . . . . Transportation will play a huge role in our Nation's ability to remain competitive [in] the global marketplace. Yet, access to sufficient resources with which to accomplish what needs to be accomplished remains an unresolved issue for us all."

Prior to his appointment, Capka served as the deputy administrator of FHWA. In this capacity, he helped to prepare the transportation reauthorization proposal and to shape the management of highway megaprojects across the country.

Before joining FHWA, Capka served as chief executive officer/executive director of the Massachusetts Turnpike Authority (MTA), where he directed oversight of the $14.5 billion Central Artery/Tunnel Project ("Big Dig") in Boston, the largest and most complex infrastructure project ever in the United States.

Prior to his position with MTA, Capka retired from a 29-year military career in the U.S. Army Corps of Engineers, where he served in the United States, Europe, the Pacific, and the Far East. Before retirement as a U.S. Army brigadier general, Capka's most recent assignments included division engineer and commander of the Corps' South Atlantic Division.

In 1997, he led the Federal flood system recovery response to the unprecedented California floods that severely damaged the Sacramento and San Joaquin flood control systems. The effort earned specific praise from both then-President William J. Clinton and then-Governor of California Pete Wilson.

Capka is a graduate of the United States Military Academy at West Point and holds a master's in engineering from the University of California, Berkeley, and a master's in business administration from Chaminade University of Honolulu. He is a professional engineer, registered in the Commonwealth of Virginia. As a result of his military service, he was awarded the Distinguished Service Medal, the Defense Superior Service Medal, and the Legion of Merit.

J. Richard Capka, seen here in the middle, was sworn in as the 16th FHWA Administrator by then-Acting Secretary of Transportation Maria Cino (left) and then-Secretary of Transportation Norman Y. Mineta (right).

Kendall Named Executive Director of Highway Funding Commission

A new Federal commission to study ways of paying for the Nation's highway and transit systems now has an executive director. In May 2006, then-Transportation Secretary Norman Y. Mineta named Quintin C. Kendall to head up the new Surface Transportation Policy and Revenue Commission. The 12-member panel met for the first time on May 24, 2006, in Washington, DC.

"This commission will create the roadmap we need to navigate the financial future of our highway and transit networks," Mineta said. "Quintin has the skills necessary to help the commission accomplish its assignment."

Kendall will be responsible for the day-to-day operations of the commission, including the scheduling of meetings and hearings, oversight of administrative support to the commission members, and development of the commission's final product, a report to Congress due July 1, 2007.

Kendall joined USDOT in 2002 as Secretary Mineta's White House liaison before becoming the deputy assistant secretary for management and budget in 2005.

Internet Watch

By Kevin Monaghan

NHI Launches Updated Web Site And New Courses

On June 5, 2006, the National Highway Institute (NHI) launched its much-anticipated improved Web site at www.nhi.fhwa.dot.gov. The updated NHI Web site features user-friendly navigation and an expanded e-commerce module that enables participants to enroll in and pay for courses.

New and Improved Features

Users can easily browse the NHI training catalog for course information and scheduled sessions. In addition to searching by keyword, title, and course number, users also can find more details by using advance search functions, including location, course level, and session dates. They also can learn whether a course is instructor-led or Web-based, and they can visit the new NHI store to purchase copies of course materials.

NHI also has improved Web conferencing and host requests by adding new functions. Users can complete online requests quickly and save contact information for future submissions.

The new resources section of the Web site houses essential tools for NHI course development and delivery. The section includes online presentations, style guides, templates, and ideas for the successful implementation of NHI courses. In addition, NHI instructors are able to complete online registration and become part of the NHI instructor community that facilitates the exchange of ideas and information, enabling NHI to continually improve in meeting participants' training needs.

In addition, the NHI Web site now provides enhanced customer service through new security features, including a login component. Users now register to access certain areas of the site by creating a user ID and password at www.nhi.fhwa.dot.gov/NHIUPLR/Login.aspx.

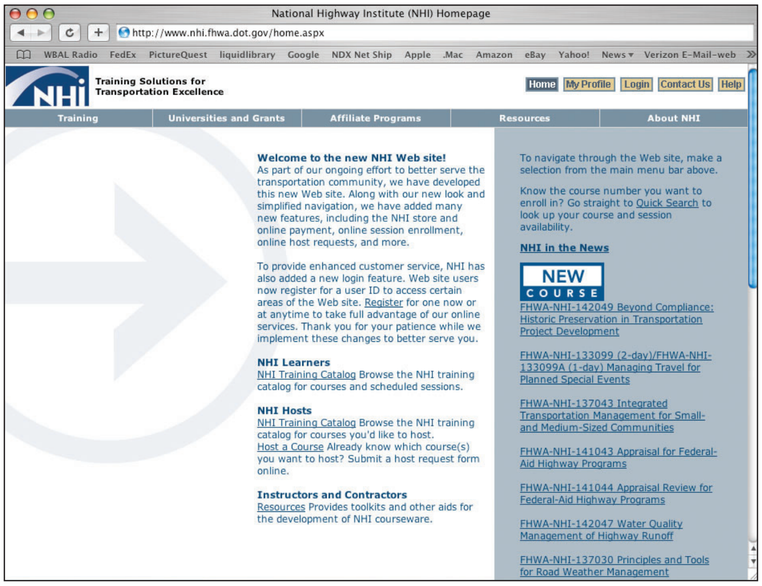
Updated Course Offerings

In addition to improving the Web site, NHI has added the following new courses:

- Underwater Bridge Inspection (FHWA-NHI-130091)—The latest update to the National Bridge Inspection Standards, which became effective January 13, 2005, requires bridge inspection training for all divers conducting underwater inspections. Course topics include methods of underwater inspection, underwater material deterioration mechanisms and inspection techniques, scour inspection techniques, and underwater element level rating.
- Managing Travel for Planned Special Events (2-day, FHWA-NHI-133099, and 1-day, FHWA-NHI-133099A)—These courses provide practitioners with a working knowledge of the techniques and strategies involved in successfully planning and operating traffic for special events such as parades and sporting events. Practitioners will gain an understanding of the collective tasks facing multidisciplinary and interjurisdictional stakeholder groups charged with the development and implementation of solutions to acute and systemwide impacts on travel during a planned special event.
- Integrated Transportation Management for Small- and Medium-Sized Communities (FHWA-NHI-137043)—This is a 1-day introductory course aimed at helping those involved in the planning, design, implementation, and operation of intelligent transportation systems (ITS) in small- and medium-sized communities. This course also introduces the use of Advanced Transportation Management Systems and Advanced Traveler Information Systems when deployed in small- and medium-sized communities.
- Improving Highway Safety with Intelligent Transportation Systems (FHWA-NHI-137044)—This is a 2-day course aimed at increasing the awareness of the potential to be gained by implementing highway safety improvements through the deployment of ITS technologies at the highway system, mainstream (highway improvement project), and stand-alone project level. The course also accelerates the introduction and evaluation of ITS applications by increasing recognition of their contributions to making highways safer. The course surveys the participants on their experiences deploying ITS for highway safety improvements and reviews procedures and requirements for safety strategic planning and the ITS deployment process.

For a complete description of these courses, visit the improved NHI Web site at www.nhi.fhwa.dot.gov. If you have any questions, contact the NHI Training Team at 703-235-0534 or nhitraining@fhwa.dot.gov.

Kevin Monaghan is a contractor for NHI.



NHI's improved Web site is shown here.

NATIONAL HIGHWAY INSTITUTE

Training Update

Revised Uniform Act Leads to Update Of the Advanced Relocation Course

A number of State departments of transportation (DOTs) have experienced loss of institutional knowledge through attrition, downsizing, and retirement. In addition, Local Public Agencies (LPAs) are carrying out more and more Federal-aid projects. The result is LPA staff people who may not be right-of-way professionals and have widely different levels of experience.

In January 2005, the final rule for the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 as amended (Uniform Act) was revised. In accordance with these changes, the National Highway Institute's (NHI) course Advanced Relocation (FHWA-NHI-141030) was updated to reflect the most current regulatory information. This is the first of the Federal Highway Administration (FHWA) and NHI real estate courses to be revised to reflect the changes in the rule.

This course provides a mechanism to convey answers to complex relocation assistance questions, but also assists by providing attendees with a framework for addressing similar questions that they will encounter during the performance of their duties.

FHWA wants to ensure that those who are displaced as a result of a federally aided project or program are provided appropriate benefits and treatment. One way to do this is by ensuring that State DOT and LPA personnel have an appropriate understanding of the requirements.

FHWA has offered the Advanced Relocation course for 6 years. The course is much requested by the right-of-way community. This version represents the first major revision with significant adult-learning enhancements.

The response has been extremely positive. "I can't say enough good things about NHI's updated Advanced Relocation course," said Sam Hester, assistant division administrator for right-of-way and utilities for the Virginia Department of Transportation. "I observed the 3-day pilot and found the course materials excellent and well presented by qualified, highly knowledgeable instructors. Further, the instructors took steps to incorporate our State policies and practices in their presentation, which made it extremely relevant to those attending. In fact, the participants were engaged throughout the entire 3 days of the session."

The suggested prerequisites for this course are the completion of the Basic Relocation course (FHWA-NHI-141029) and the Web course Real Estate Acquisition Under the Uniform Act: An Overview (FHWA-NHI-141045), or approximately 1 year of experience working in the relocation program.

This course relies on traditional instructor-led segments, videos, and case studies with group presentations of case study answers. The course also employs group interaction, Federal regulations, and other course materials targeted at solving problems.

By the end of the course, participants will be able to do the following:

In NHI's Advanced Relocation course, attendees determine eligibility for certain payments for those who were relocated and buy a new home, such as the couple shown here.

- Explain the principles that govern relocation provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 and implementing regulations.
- Describe at least three factors involved in difficult relocation subject areas.
- Describe issues that may arise when developing advisory assistance plans for difficult relocation areas.
- Determine eligibility for certain relocation payments in difficult relocation cases.
- Determine challenging issues when calculating complex nonresidential moving costs.
- Calculate complex nonresidential moving costs.

The course is designed for Federal, State, and local public agencies, FHWA personnel, right-of-way contractors, and other interested persons.

For more information on the course, contact Arnold Feldman at 202-366-2028 or arnold.feldman@fhwa.dot.gov. To schedule a course, contact the NHI Training Coordinator at 703-235-0534 or nhitraining@fhwa.dot.gov. To obtain information about all NHI courses, access the course catalog at www.nhi.fhwa.dot.gov or contact NHI at 703-235-0500 (phone) or 703-235-0593 (fax).

Communication Product Updates

Compiled by Zac Ellis of FHWA's Office of Research and Technology Services

Below are brief descriptions of products recently published online by the Federal Highway Administration's (FHWA) Office of Research, Development, and Technology. Some of the publications also may be available from the National Technical Information Service (NTIS). In some cases, limited copies are available from the 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)

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

R&T Product Distribution Center, HRTS-03
Federal Highway Administration
9701 Philadelphia Court, Unit Q
Lanham, MD 20706
Telephone: 301–577–0818
Fax: 301–577–1421

For more information on research and technology publications from FHWA, visit the Turner-Fairbank Highway Research Center's Web site at www.tfhrc.gov, FHWA's Web site at www.fhwa.dot.gov, the National Transportation Library's Web site at http://ntl.bts.gov, or the OneDOT information network at http://dotlibrary.dot.gov.

Interactive Highway Safety Design Model (IHSDM): Safer Roads Through Better Design
Publication No. FHWA-HRT-06-100

This IHSDM brochure provides information on a suite of evaluation modules that offer comprehensive assessment capabilities. A product of FHWA's Safety Research and Development Program, IHSDM's software analysis tools help individuals involved in the highway design process evaluate the safety and operational effects of geometric design decisions, ensuring that the highways of today and tomorrow are as safe as possible.

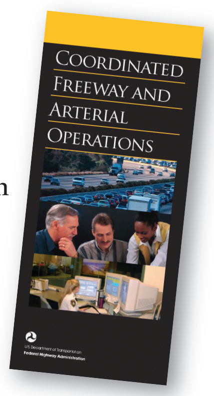
There are five evaluation modules in the public release of IHSDM for two-lane rural highways: Policy Review, Crash Prediction, Design Consistency, Intersection Review, and Traffic Analysis. Research and development efforts are underway to add evaluation capabilities for multilane rural highways and urban and suburban arterials. Citizens today want agencies to create context sensitive designs, yet demand that safety not be compromised in the process. IHSDM evaluates design policy and safety for existing and proposed designs, and helps agencies make, justify, and defend geometric design decisions in this environment.

For details and updates on the release of IHSDM, visit the IHSDM Web site, www.tfhrc.gov/safety/ihsdm/ihsdm.htm. The site also includes information about training and technical support, and links to current research and other resources. The brochure can be viewed online at www.tfhrc.gov/safety/ihsdm/pubs/06100. Printed copies are available from FHWA's R&T Product Distribution Center.

Coordinated Freeway and Arterial Operations Handbook and Brochure
Publication Numbers: FHWA-HRT-06-095 (Handbook) and FHWA-HRT-06-094 (Brochure)

Coordinated freeway and arterial (CFA) operations are the implementation of policies, strategies, plans, procedures, and technologies that enable transportation practitioners to manage traffic on freeways and adjacent arterials as a single corridor, rather than as individual transportation facilities. The result of CFA operations is improved mobility and safety and reduced environmental impacts throughout the corridor.

The purpose of the *Coordinated Freeway and Arterial Operations Handbook* is to provide direction, guidance, and recommendations on how transportation agencies can coordinate freeway and arterial street operations proactively and comprehensively. The first of its kind, this introductory handbook focuses on coordinating the operations of various types of facilities that typically are operated by separate organizations with separate missions. The handbook also can assist with the advanced planning and management of travel on freeways and arterials with various kinds of congestion, such as high traffic volumes from special events or work zone-related lane closures.



The intended audience is transportation professionals involved with legislation, policy, program funding, planning, design, project implementation, operations, or maintenance. The handbook is available in hardcopy from NTIS and electronically on the "Transportation Management Center Pooled-Fund Study" Web site at http://tmcpfs.ops.fhwa.dot.gov/cfprojects/new_detail.cfm?id=48&new=0. The NTIS order number is PB2006-110503. In addition, a limited supply is available from FHWA's R&T Product Distribution Center.

A brochure (FHWA-HRT-06-094) is also available that promotes the handbook, explains the benefits of CFA, and answers questions regarding CFA operations. The brochure can be viewed online at www.tfhrc.gov/its/pubs/06094/index.htm. A limited supply is available from FHWA's R&T Product Distribution Center.

Multiyear Plan for Bridge and Tunnel Security Research, Development, and Deployment
Publication No. FHWA-HRT-06-072

Transportation systems are identified as one of the critical infrastructures under Homeland Security Presidential Directive-7. They are essential for mobility and commerce, and play a critical role in times of crisis. The Nation's highways are essential for evacuation and for the response and recovery effort. The highway network has approximately 600,000 bridges and 300 tunnels, and many of these are considered critical structures and/or part of essential corridors. A damaged bridge or tunnel can have an enormous impact on a city, a region, and possibly the Nation. Although FHWA actively conducts research and development to mitigate natural hazards such as flooding and scour, earthquakes, wind, and wind-induced events, designing for security is a new task. Because the challenge is tremendous, FHWA has led multiple outreach sessions to identify needs and gaps, and to evaluate input provided by experts in the field of bridge engineering and others. FHWA has proposed a multiyear plan to design highway bridges and tunnels for security.

The plan can be viewed online at www.tfhrc.gov/structur/pubs/06072/index.htm and is available in hardcopy from NTIS. The NTIS order number is PB2006-110324. A limited supply also is available from FHWA's R&T Product Distribution Center.

Office of Research, Development, and Technology Performance Plan: Fiscal Year 2006–2007
Publication No. FHWA-HRT-06-037

FHWA's *Office of Research, Development, and Technology (RD&T) Performance Plan* is a 2-year plan that serves as a roadmap for the office's research program and directs efforts to improve operations and enhance services. The RD&T program directly supports the strategic goals of FHWA and USDOT, and helps FHWA achieve its mission of enhancing mobility through innovation, leadership, and public service. The *RD&T Performance Plan* describes the research, services, and other RD&T activities conducted in support of the FHWA R&T program. The *RD&T Performance Plan* also illustrates how RD&T activities are aligned with the strategic goals and objectives of FHWA and USDOT. The plan includes a detailed list of projects and target completion dates developed in conjunction with headquarters and field offices as part of multiyear R&T program plans.

The publication is online at www.tfhrc.gov/about/perfplan0607/index.htm.

Evaluation of Safety, Design, and Operation of Shared-Use Paths
Publication No. FHWA-HRT-05-139

This TechBrief is a summary of *Evaluation of Safety, Design, and Operation of Shared-Use Paths: Final Report* (FHWA-HRT-05-137). Shared-use paths are paved, offstreet travelways that serve bicyclists, pedestrians, and other nonmotorized modes of travel. FHWA and a team of researchers led by the North Carolina State University Department of Civil, Construction, and Environmental Engineering have developed a new method to estimate the level of service on shared-use paths.

The final report is available from NTIS. A limited number of copies of the final report also are available from FHWA's R&T Product Distribution Center.

Computer-Based Guidelines for Concrete Pavements, Volume III: Technical Appendices
Publication No. FHWA-HRT-04-127

This report documents enhancements incorporated into the HIgh PERformance PAVing (HIPERPAV™ II) software. Enhancements made within this project include the addition of two major modules: a module to predict the performance of jointed plain concrete pavement (JPCP) as affected by early-age factors, and a module to predict the early-age behavior (first 72 hours) and early life (up to 1 year) of continuously reinforced concrete pavements (CRCP). Two additional FHWA studies also are incorporated into the report. One of the studies predicts dowel bearing stresses as a function of environmental loading during early age, and the other includes a module for optimization of concrete paving mixes as a function of 3-day strength, 28-day strength, and cost. FHWA incorporated the additional functionality by reviewing and prioritizing the feedback provided by users of the first generation of the software, HIPERPAV I.

This volume includes the following technical appendices: (A) Annotated outline of the references investigated during this project; (B) Description of the models selected for incorporation in HIPERPAV II; (C) Field investigation of JPCP and CRCP sites used for model validation; (D) Validation of the enhanced HIPERPAV II computer guidelines; and (E) Finite-difference temperature model validation. This is the third and last volume in a series of three volumes that document the different tasks carried out in accomplishing the objectives of this project. The other two volumes are *Computer-Based Guidelines for Concrete Pavements, Volume I: Project Summary* (FHWA-HRT-04-121) and *Computer-Based Guidelines for Concrete Pavements, Volume II: Design and Construction Guidelines and HIPERPAV II User's Manual* (FHWA-HRT-04-122).

Volume III: Technical Appendices is available from NTIS. A limited supply also is available from FHWA's R&T Product Distribution Center. *Volume I: Project Summary* is available from NTIS under order number PB2005-105417.

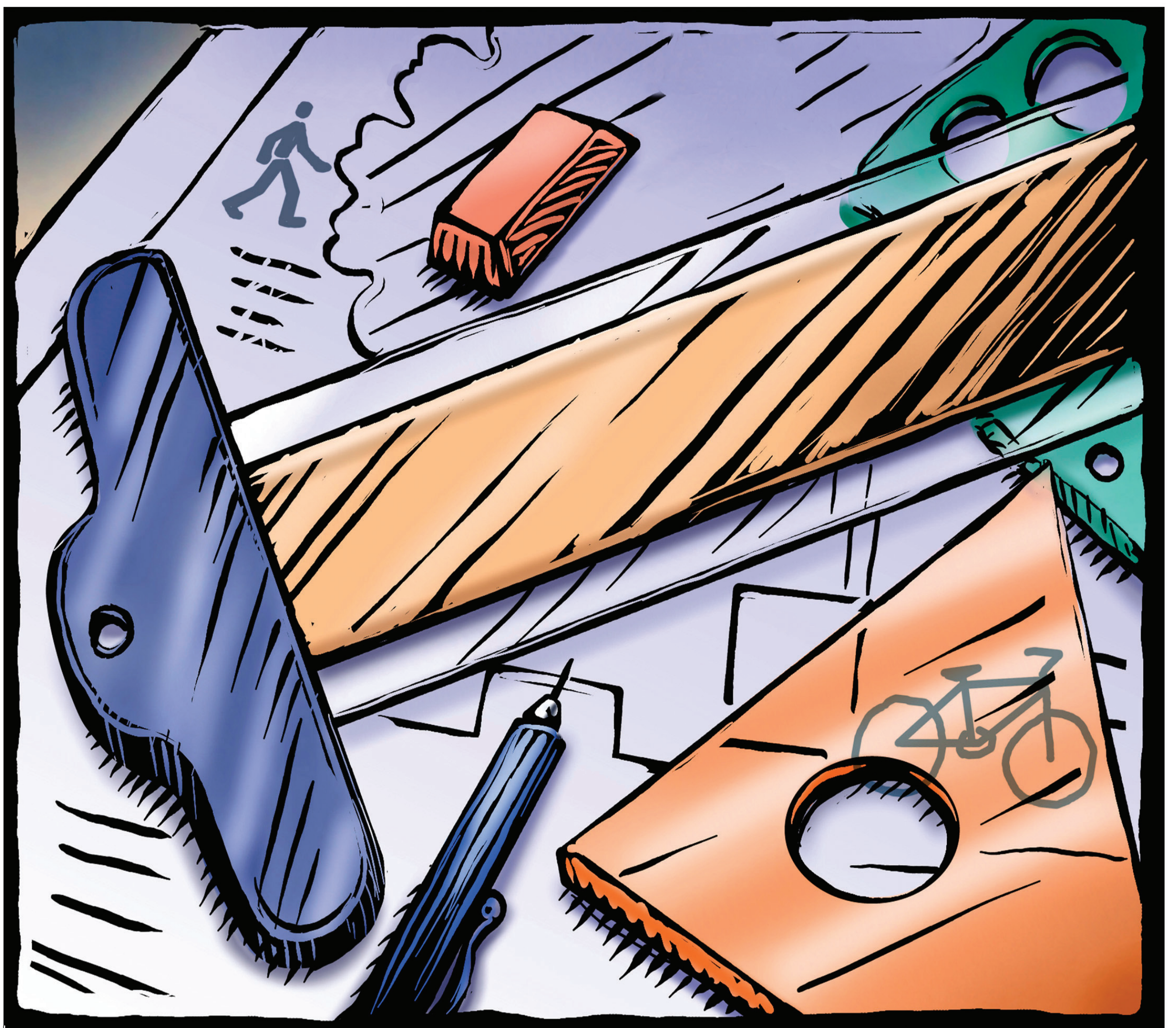
Conferences/Special Events Calendar

Date	Conference	Sponsor	Location	Contact
January 16-19, 2007	Geosynthetics 2007	Industrial Fabrics Association International, Geosynthetic Materials Association, North American Geosynthetics Society, International Geosynthetics Society, and Geosynthetic Institute	Washington, DC	Jill Rutledge 651-225-6981 jmrutledge@ifai.com www.geoshow.info
January 21-25, 2007	TRB 86th Annual Meeting	Transportation Research Board (TRB)	Washington, DC	Linda Karson 202-334-2934 lkarson@nas.edu www.trb.org/meeting
March 25-27, 2007	Lifesavers 2007 Conference (National Conference on Highway Safety Priorities)	Lifesavers	Chicago, IL	Mary Lofgren 703-922-7944 marylofgren@cox.net www.lifesaversconference.org
March 25-28, 2007	ITE 2007 Technical Conference and Exhibit	Institute of Transportation Engineers (ITE)	San Diego, CA	Christina Denekas 202-289-0222 ite_staff@ite.org www.ite.org
June 3-8, 2007	First North American Landslide Conference	Association of Environmental & Engineering Geologists, Geo-Institute, American Rock Mechanics Association International, Canadian Geotechnical Society, and TRB	Vail, CO	Keith Turner 303-273-3802 kturner@mines.edu www.mines.edu/academic/geology/landslidevail2007
June 4-6, 2007	3rd National/1st International Conference on Performance Measurement	Federal Highway Administration (FHWA), Federal Transit Administration	Irvine, CA	Martine Micozzi 202-334-3205 mmicozzi@nas.edu http://trb.org/news/blurb_detail.asp?id=6236
June 24-27, 2007	9th International Conference on Low-Volume Roads	TRB, U.S. Department of the Interior Bureau of Indian Affairs, FHWA, U.S. Department of Transportation, U.S. Department of Agriculture Forest Service, U.S. Army Corps of Engineers Engineer Research and Development Center, and U.S. Environmental Protection Agency	Austin, TX	G.P. Jayaprakash Michael DeCarmine 202-334-2952 trbmeetings@nas.edu9lvr@nas.edu www.trb.org/conferences/9lvr
July 8-11, 2007	Pipelines 2007	American Society of Civil Engineers	Boston, MA	Leonore Jordan 800-548-2723 ljordan@asce.org http://content.asce.org/conferences/pipelines2007
October 9-12, 2007	ARTBA Annual Convention	American Road & Transportation Builders Association (ARTBA)	Fort Lauderdale, FL	Ed Tarrant 202-289-4434, ext. 204 etarrant@artba.org www.artba.org

Train the transportation professionals of tomorrow...

...University course on bicycle and pedestrian safety is ready.

Professors and transportation practitioners can download the Federal Highway Administration University Course on Bicycle and Pedestrian Transportation to train the transportation professionals of tomorrow. The collegiate-level, modular course contains 24 lesson workbooks and scripted Microsoft® PowerPoint® presentations that span a wide range of topics, including an introduction to bicycling and walking issues, planning and designing for bicycle and pedestrian facilities, and supporting elements and programs. To view and download the course, go to ftp://universityguest:Univ3rsity@fhwaftp.fhwa.dot.gov /university. For more information, email: ann.do@fhwa.dot.gov.



U.S. Department of Transportation

Federal Highway Administration

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