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Safe Routes to School

Safety Colors

Retaining Walls

U.S. Department of Transportation

Federal Highway Administration

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

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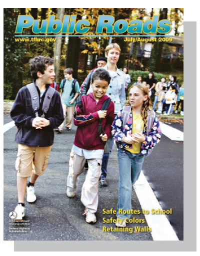

Front cover—These students (and the mother behind them) are participating in the Safe Routes to School program. More than 5,200 schools in 50 States and the District of Columbia benefit from this Federal program to encourage more walking and bicycling to school. See article "Safe Routes to School—Making a Big Difference Via Small Steps" on page 2 of this issue of PUBLIC ROADS. *Photo by Tamara Lackey.*

Back cover—Crews with the Washington State Department of Transportation (WSDOT) and its contractor are conducting geotechnical drilling exercises along the I-90 Snoqualmie Pass East Project corridor through the high mountain slopes of the Cascades. Crews are gathering data about rock and soil conditions in order to move forward with project design plans. For more on this project, see "Reconstructing Snoqualmie Pass" on page 16 of this issue of PUBLIC ROADS. *Photo by WSDOT.*

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Guest Editorial

Introducing . . . Office of Technical Services

The Nation faces tough challenges ahead, addressing the impacts of climate change, tackling growing traffic congestion, and improving the Nation's aging infrastructure. All these areas offer real opportunities for the U.S. Department of Transportation (USDOT) to step up and provide leadership. It is the *people* of USDOT, with the critical support of partners and stakeholders across the country, who are the keys to success.

Within the Federal Highway Administration (FHWA), one example of providing leadership and value to partners and stakeholders is the recent reorganization of the Office of Technical Services (OTS). By bringing together the Resource Center, the National Highway Institute (NHI), and the Technology Partnership Programs under one office, FHWA has strengthened its ability to advance the agency's goals and objectives and to deliver critical services more strategically. The work each office was doing before will continue—from developing and delivering training to providing technical assistance and helping to deploy new technologies. But the reorganization will generate new opportunities to work collaboratively, form stronger relationships, and communicate more effectively with partners and stakeholders, all while continuing to provide excellent customer service.

The new OTS already is successfully supporting a variety of agency priorities. The Resource Center's Technical Service Teams are providing invaluable support by helping develop and deliver a series of seminars aimed at local agencies, providing staff for the national review teams, and assisting with Disadvantaged Business Enterprise requirements. The Resource Center also joined forces with NHI to support a combined safety and operations disciplines seminar.

NHI recently developed a customized course to help ensure that recent hires can hit the ground running. The pilot, which combined aspects from three NHI courses—Federal-Aid Highways 101, Highway Program Financing, and Contract Administration Core Curriculum—was delivered in a week-long session to 25 new employees from the western divisions. As State travel budgets continue to shrink, NHI is focused on converting existing courses into Web-based or other distance-learning opportunities.

The Technology Partnership Programs continue to focus on enhancing partnerships and supporting the Local Technical Assistance Program (LTAP) and Tribal Technical Assistance Program (TTAP) centers. A recent effort involved creating a workgroup that developed a safety toolbox, which will reside on the LTAP/TTAP clearinghouse Web site. The Technology Partnership Programs also are reaching out to community colleges to help provide transportation workforce development.

At the end of the day, whether housed at USDOT headquarters, in a division office, or in the OTS, by maintaining the "all on the same team" perspective, the department's future will be as successful as its past and continue to make a difference for the American people.

Amy C. Lucero
Director, Office of Technical Services
Federal Highway Administration

Safe Routes To School

Making a Big Difference Via Small Steps

by Rebecca Crowe, Raquel G. Rivas, and Kathy Norcross Watts

This nationwide program is helping reduce traffic congestion while tackling several other societal issues by encouraging children to walk or bicycle to class safely.

Ever hear someone say, "In my day, I walked to school 5 miles, barefoot, uphill both ways, in the snow . . ."?

Today, schoolchildren do not walk those fabled 5 miles, much less uphill both ways, but they—and their parents—do face modern-day challenges in their trips to and from school: traffic congestion, fuel costs, air pollution, and safety issues, not to mention reduced availability of schoolbus trips.

The Centers for Disease Control and Prevention notes that 30 years ago it was common to see children walking or bicycling to school. Today, according to a study published in the *American Journal of Preventive Medicine,* less than half of the students who live within a mile of school go there even one day a week by walking or bicycling.

A relatively new Federal program, Safe Routes to School (SRTS), addresses several of these challenges

The Safe Routes to School program addresses physical activity, environmental pollution, and budget challenges facing schools. This boy and girl enjoy walking to school.
Photo: Tamara Lackey.

through three key goals: encouraging children to walk and bicycle to school; improving their safety along the way; and reducing traffic, fuel consumption, and air pollution near schools—all helping to create livable communities.

In 2005, the U.S. Congress passed the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). Section 1404 of the transportation legislation designates $612 million in Federal transportation funds for the SRTS program. The funds are distributed through each State's department of transportation (DOT). By way of bonus benefits, the program helps address other issues so much in the news: reduced school budgets for purchasing, operating, and maintaining schoolbuses; childhood obesity; and the need for community revitalization.

Nearly 4 years after the passage of SAFETEA-LU, a network of State coordinators, local program leaders, and advocates, coupled with an increasing understanding of what works, is helping the Federal program achieve the goals that Congress intended. Each State DOT administers its own program and develops its own procedures to select projects for Federal funding.

As of April 1, 2009, all 50 States and the District of Columbia were participating in SRTS and had announced a combined total of $355.2 million in Federal funding for State or local SRTS activities. In addition, 5,200 schools were participating, indicating progress in meeting SAFETEA-LU's first two goals of encouraging children to walk or bike to school and getting them there safely. Being a young program, SRTS does not yet have nationwide aggregate data. But the SRTS program collects information on a voluntary basis and has received baseline data from 2,534 schools in 49 States.

"The Safe Routes to School program provides State DOTs with 100 percent Federal aid to increase the safety of the Nation's children and increase the livability of our communities," says Associate Administrator for Safety Joseph S. Toole of the Federal Highway Administration (FHWA). "The program has a lot of flexibility, and States have been very creative in how they use these funds. We know Safe Routes to School projects are reducing traffic congestion, improving infrastructure, and most important, providing our children with a safe route to school."

Certainly, local governments are enthusiastic about the program. "Having children walk to school on safe pathways is beneficial in many ways," says Mayor Jimmy Harris of Brevard, NC, which will soon be constructing a new SRTS trail. "From a health perspective to reducing traffic congestion, children walking to school, as they have for many years, is smart and wise. I cannot find any negatives in children beginning their day by being in the fresh outdoors before sitting for several hours in classrooms."

The SRTS Story

To address the program goals outlined in SAFETEA-LU, FHWA established the SRTS program in 2005 and the National Center for Safe Routes to School (NCSRTS) in 2006. The University of North Carolina Highway Safety Research Center maintains NCSRTS with funding from FHWA. Partners in the program include the American Association of State Highway and Transportation Officials, America Walks, Governors Highway Safety Association®, Institute of Transportation Engineers, and Toole Design Group.

NCSRTS supports the work of State DOTs by serving as a clearinghouse for information on the program. Through a Web site, online resource guide, tip sheets, and listservs, NCSRTS provides technical assistance to the public and SRTS State coordinators. The center also coordinates information sharing among the States, develops training courses to enable communities to implement best practices, and collects data from SRTS programs around the country to help set milestones and evaluate the progress of those programs nationwide. To learn more, visit www.saferoutesinfo.org.

Developing an SRTS Program

Two types of funding for an SRTS program are available. One is for infrastructure projects such as engineering improvements, and the other is for noninfrastructure activities such as education, enforcement, and encouragement programs.

To inform local communities about the program, States use a variety of strategies. The Delaware Department of Transportation (DelDOT), for example, mails information directly to elementary and middle school principals, explains SRTS State Coordinator Sarah Coakley. "We also work with partners such as the Delaware Department of Education's Connections to Learning Partnership Council, Nemours Health and Prevention Services, Sussex Child Health Promotion Coalition, Delaware Division of Public Health, and Delaware Coalition for Injury Prevention to inform stakeholders about the SRTS program and the availability of Federal funding," Coakley says.

A typical framework for establishing an SRTS program at the local level involves the following steps, based on what has worked in a number of communities. The steps are meant to provide guidance, but getting things done may require different approaches or performing the steps in a different order.

1. *Bring together the right people.* Community members with diverse expertise sharing concerns, interests, and knowledge can help with tackling a variety of relevant issues.
2. *Hold a kickoff meeting to establish a vision.* Participants share their vision for the school 5 years in the future.
3. *Gather information and identify issues.* Collecting information can help to identify needed program elements and provide a means to measure the program's impact.
4. *Identify solutions.* Solutions will include a combination of education, encouragement, engineering, and enforcement strategies. Safety is always the first consideration.
5. *Make a plan.* It doesn't need to be lengthy but should include a time schedule.
6. *Get the plan and people moving.* Hold a kickoff event such as a Walking Wednesday or a local adaptation of the International Walk to School Day.
7. *Evaluate, adjust, and keep moving.* To sustain the program, consider encouraging additional program champions and letting people know about your successes.

Deploying a new Federal program in 50 states and the District of Columbia in a short timeframe required different approaches in different States. Some, such as Michigan and California, had previous State funding, training, and guidelines for SRTS-like programs. Most States had to start from scratch.

Florida SRTS State Coordinator Pat Pieratte says, "We opened the first call for applications in November 2006. FDOT [Florida Department of Transportation] works on a 5-year work program, so we attempted to award as much of the 5-year allocation of SRTS funds as possible with the first call for applications. SRTS contacts at our seven districts helped spread the word about the new program." The third call for applications closed April 2009.

Part of the strength of SRTS is its adaptability to communities of all sizes, including those with limited resources. As the following sampling shows, a number of communities have embraced SRTS to improve the lives of their schoolchildren and adults.

"Walking Schoolbuses" In Vermont

Green Street School is located within a quarter-mile of downtown Brattleboro, a town of 8,160 in southern Vermont. The school has 268 students from kindergarten through sixth grade. Approximately 200 of the students live within a 2-mile (3-kilometer) radius of the school. Parents' primary safety concerns were the traffic speed and volume on Green Street.

In 2006, Green Street School received an $18,000 Federal SRTS grant and in 2008 another $6,975 grant through the Vermont Agency of Transportation (VTrans), with both allocated for noninfrastructure activities.

Alice Charkes, the SRTS coordinator for the elementary school and a high school French teacher, worked with a graphic designer to develop newspaper advertisements to remind motorists to "Please drive the speed limit" and "Stop for pedestrians in crosswalks." Additional ads remind homeowners and other residents to shovel sidewalks and trim hedges along the SRTS route. The SRTS program, the Safe Kids Coalition, and the Brattleboro Area Bicycle and Pedestrian Coalition funded the ads.

Students at the elementary school can walk to school more safely after the school's SRTS program achieved a 40 percent reduction in the number of cars that speed in the school zone, according to traffic data from the Windham Regional Commission.

In the morning, speeding cars decreased from 59 percent to 21 percent. In the afternoon, the numbers went slightly up from 33 percent to 37 percent.

In addition, the school established "walking schoolbuses," which are groups of children accompanied by adults for the walk to and from school. The group picks up students as it passes by their homes or a central meeting place. The number of walking schoolbuses increased steadily, tripling from 3 in 2006 to 11 in 2008.

When the school received the first grant, 25 parents immediately volunteered for the school's SRTS program and regularly led walking schoolbuses, rode bicycles to school with their children, and handed out "I walked/biked to school today!" stickers at the school doorway.

Other aspects of the program include Walking and Wheeling Wednesdays, which promote use of the SRTS route 1 day a week. In fall 2008, this promotion saw a 100 percent increase in participation, plus creation of a Winter Walkers club.

Charkes believes that the timing of the school's 2006 SRTS grant coincided with a willingness to change. "I think the school was at a stage where it was ready," she says, adding that now SRTS is considered an integral part of how the school works.

For one thing, SRTS is integrated into the school's Finding Fitness

Economic Development

Brevard, NC, a town of 6,700 in the Appalachian Mountains, is building a Safe Routes to School (SRTS) walking and bicycling path to connect two of its schools with densely populated residential neighborhoods. Thanks to a unified front by the city council and staff, plus a deliberate effort to build an effective relationship with the North Carolina Department of Transportation (NCDOT), Brevard has overcome economic adversity to begin creating a safe, pedestrian-friendly community.

The town's major employers—three manufacturing companies—all closed down within the past decade. Mayor Jimmy Harris says, "At one point, Brevard had North Carolina's highest unemployment rate." Despite this calamity, the city council adopted a comprehensive pedestrian plan in 2006, which included expansion of the sidewalk system plus existing hiking/biking paths to connect downtown

Isabelle (5) and Hazel (9) and their mother Sara Freeman stroll on one of the trails in Brevard, NC, that will eventually connect through a sidewalk and path system with the new trail that will be constructed in part with SRTS funds. *Photo: Brad L. Burton, Assistant Planning Director, City of Brevard.*

These students are walking to school on a snowy morning. In addition to making physical improvements, many participating schools are reinforcing safe walking and bicycling behavior through classroom lessons and skills practice.

Alice Charkes

Fundraiser, which challenges students to raise their fitness levels over the course of 4 weeks each fall, as well as several other health initiatives. The program also was linked to the school's TV/Screen Turn-Off Week, during which the school hosted a bicycling/walking event for one night. Participation in International Walk to School Day grew from 133 students in 2006 to 215 in 2008.

Charkes measures progress with class tallies, parent surveys, punch cards, and participant counts. She says that progress comes from one parent and one child at a time, and that those incremental increases add up. In the first year of the program, Charkes taught a bicycle safety curriculum titled "Bike Smart! Youth Bicycle Safety Program" and held bicycle rodeos where children practice basic bicycling techniques. Her workshops reached 150 children, or 60 percent of the students at Green Street School. The second year, she added WalkSmart! Active Schools lessons and reached 90 percent of the student population.

Green Street School's SRTS team consists of the school principal, staff, the Parent Teacher Organization, the head crossing guard, the Brattleboro Department of Public Works director, the police department, and a Windham Regional Commission planner. Other support has come from Brattleboro Memorial Hospital and the Vermont Bicycle & Pedestrian Coalition. Charkes communicates regularly with the town manager, the selectboard, the traffic safety committee, and State legislators.

Safety for Students In Delaware

Three elementary schools in Smyrna, DE, are participating in SRTS: Smyrna

for Small Communities

with nearby Pisgah National Forest. The system also will connect the town's schools and its two colleges.

The goal was to increase safety for schoolchildren, students, retirees, and young families, while enhancing the community's quality of life and thereby attracting new economic development. After constructing the first three segments, the town turned to the SRTS program. "On a practical level," says Brevard Planning Director Josh Freeman, "SRTS opened funding doors. Also, we have miles and miles of proposed sidewalks; the program gave us a useful way of thinking about priorities."

The next priority for the pedestrian infrastructure is a 1-mile (1.6-kilometer) asphalt path to connect two schools, public housing, a medical clinic, a boys and girls club, and the existing sidewalk system. The total cost is $650,000, representing $350,000 allocated from the city's capital reserve, a $250,000 SRTS grant from NCDOT, and $50,000 that the city raised by selling engraved brick pavers at $100 each. The pavers will be set in an amenity area of the path featuring benches and a water fountain.

Then came a snag: To avoid the possibility of worsening flooding conditions at two stream crossings, engineering changes were needed to guard against a potential rise in flood levels. The redesign employs extended culverts and an exception to move the path closer to the road. Ultimately, NCDOT accepted an encroachment agreement for the path relocation.

"The lesson learned for me," says Freeman, "is we waited too long to engage NCDOT in the review process." He recommends that communities allow 2 to 3 years in total, including 12 months for obtaining funding through the local council's budget cycle, 6 to 12 months for design, and 6 months for construction. Now that the encroachment agreement is almost finalized, Freeman hopes to begin construction shortly after school starts in fall 2009.

Mayor Harris says, "We're not necessarily doing this for economic development, but we're glad for job growth if that's a byproduct. We're doing this because it's the right thing to do. We've got community support, and we have support from the State. The timing is right. And this is a win-win for our community. We're building it one paver at a time."

—Norah Davis, Editor of PUBLIC ROADS

Tamara Lackey

The Federal SRTS program devotes 70 to 90 percent of funds to infrastructure improvements and 10 to 30 percent on noninfrastructure activities such as strategies to encourage students like these to walk to school.

Elementary, Clayton Elementary, and North Smyrna Elementary, where 42 percent of the students come from low-income families. DelDOT awarded the school district and the town of Smyrna $523,000 in Federal SRTS funds in 2007–2008 for sidewalks, crosswalks, and curb construction, plus educational programs at the three schools.

Thanks to collaboration between the school district, the town, and DelDOT, the improvements adjacent to North Smyrna Elementary were completed in 6 weeks, with most of the work finished before school began in August 2008. DelDOT streamlines the implementation process by administering all SRTS projects on behalf of sponsors.

"These improvements enhance safety for students who walk or bicycle by encouraging them to use safer crossings where traffic control devices are located, by completing gaps in the routes to school, by making routes accessible, and by increasing driver awareness of school routes and the presence of children," says Deborah Wicks, superintendent of the Smyrna School District.

In addition to the physical improvements, the schools reinforce walking and bicycling safely to school through classroom lessons and positive behavior support, plus posting rules for students and communicating those rules to parents via newsletters and orientations. In addition, the physical education teachers involve students in an All Children Exercise Simultaneously initiative, walks around the schools, International Walk to School Day, instruction on how to use pedometers, and lessons on the health benefits of walking and bicycling.

Car-Free Commuting In Colorado

By the second year of the Car-Free Commute program at Bear Creek Elementary School in Boulder, CO, 70 percent of students walked and bicycled to school consistently throughout the school year. At the onset of Federal funding, a student tally showed 41 percent walking or bicycling to school.

Bear Creek Elementary School was the recipient of the James L. Oberstar Safe Routes to School

Jim Kornish

These students and parents are walking to school. Early SRTS successes show increases in walking and bicycling, reduced traffic around schools, and savings in school transportation costs.

Award in 2008. The award is a tribute to Oberstar's sponsorship of the SRTS legislation in 2005 and is given annually by the NCSRTS to exemplary SRTS programs.

Since then, increased parent involvement, strong school leadership, and a portion of $36,000 in SRTS funds shared with two other schools have helped encourage nearly 75 percent of the school's 365 students to make walking and bicycling a part of their daily routines. In 2007, the Colorado Department of Transportation awarded another $73,448 in SRTS funds for encouragement programs at six schools.

Principal Kent Cruger serves as a role model for his students by hosting the Cruger Cup, a yearlong challenge to his students to arrive at school every day without a car. At the beginning of each month, the principal tries a new form of transportation such as a foot-powered scooter, a skateboard, or a unicycle, and he regularly carpools with other area principals to school district meetings.

"Although this initiative was initially adult-driven, it has been the students who have taken ownership of their own travel choices and inspired the adults around them," says Cruger.

At the school district's request, the city of Boulder conducted traffic counts during the first year of Bear Creek's Car-Free Commute program. The city counts showed a 30 percent reduction in cars and corresponding traffic congestion near the school. Through school travel tallies, students accrued 4,800 miles (7,725 kilometers) from 6,600 Car-Free Commute trips in September 2008 alone.

The school's culture is changing from motor-powered to foot-powered transportation. In parent surveys about the Car-Free Commute program, they said, "My daughter does not want to miss a day!" or "My son refuses to take the car." Students are inspired by the example set by the adults, and adults are encouraged by their children into choosing Car-Free Commute.

"We are trying to create a new culture of daily car-free habits in this young generation," concludes Vivian Kennedy, a parent volunteer.

Washington State: Saving Transportation Dollars

In 1995, the Auburn School District, in Auburn, WA, linked concerns about the high cost of pupil transportation and increased childhood obesity. The result was cooperation that led to 20 percent of the district's students walking to school. With a 2006 SRTS infrastructure grant of $121,770 from the Washington State Department of Transportation, Auburn partnered with its school district to build sidewalks and bike lanes. The school district also received an $185,000 Federal SRTS infrastructure grant for Olympic Middle School to remedy safety concerns along a heavily traveled road.

Tamara Lackey

The Safe Routes to School program aims to make routes safer for children like these to walk and bicycle to school and to encourage more safe walking and bicycling.

With these infrastructure grants, the school district has worked to increase physical activity among students. At Pioneer Elementary School, bus use has decreased from six buses to one, and 85 percent of children walk or bike to school. Jim Denton, director of transportation for the Auburn School District for 12 years, says, "We're saving $220,000 in transportation costs every year because of these kids. Not only is it working, this program is standing the test of time. Each school is finding more and more ways to participate."

He attributes the program's success to the partnerships in the school district, where 14,500 students come from 4 county schools and 19 schools in 3 towns—Auburn, Algona, and Pacific. The Auburn School District Transportation Department's partnership approach to the SRTS program was declared a Top 50 Program by the 2008 Innovations in American Government Awards competition, administered by the Ash Institute for Democratic Governance and Innovation at Harvard University's John F. Kennedy School of Government.

An added benefit has been improved academic achievement at Pioneer Elementary where students achieved the highest scores in the district. According to Denton, Principal Debra Gary attributes part of that gain to the health benefits of walking and bicycling to school.

Montana: A Renewed Sense of Community

In 2004, the Mean Streets report by the Surface Transportation Policy Project identified Billings as the least safe city for pedestrians in Montana. Parent volunteer and community health advocate Kathy Aragon decided to do something about it. As chair of the safety committee at the Highland Elementary School Parent Teacher Association, she helped institute the Go Play Billings Trails community awareness campaign.

"It's all about community awareness," says Aragon. "We have an enormous amount of collaboration."

This noninfrastructure program began in 2006 when St. Vincent Healthcare donated $5,000 to enable students from Montana State University Billings (MSUB) to develop a brochure that encourages safe walking and bicycling. Sarah Keller, assistant professor in the Department of Communication and Theatre at MSUB, codirected the effort with Aragon.

Project goals included increasing community support for construction of sidewalks, trails, bike lanes, and greenways. Additional objectives included motivating people to use these improvements, increasing pedestrian safety, and increasing the perceived benefits of walking and bicycling.

In March 2007, the Montana Department of Transportation granted $10,000 in Federal SRTS funds to the Go Play initiative. The campaign linked to nonprofit Web sites and provided information at community presentations and at a 6-mile (9.7-kilometer)-long Magic City Trail Trek and a 2-mile (3-kilometer)-long Saturday Live Fun Run/Walk, a school district fundraiser.

What's It All Add Up To?

Although each State is at a different stage of implementation, the fact that more than 5,200 schools in all 50 States are participating and $355.2 million in Federal funds have been committed to projects attests to the nationwide reach of the SRTS program.

In July 2008, the National Safe Routes to School Task Force, a federally chartered national advisory committee established by SAFETEA-LU, provided recommendations to the U.S. Department of Transportation (USDOT) and Congress for advancing the SRTS program nationwide. The task force, which is composed of experts in transportation, local government, health, and education, provided five strategies for advancing SRTS.

"We know there are other indicators of success, including increased levels of physical activity, reduced traffic congestion, and improved air quality," says Donna Smallwood, AICP, chair of the national task force and program operations manager at MassRIDES in Boston. "That's why we recommended that USDOT work with partner agencies dealing with health, education, and the environment to develop appropriate outcome measures."

NCSRTS, which focuses on measuring the program's success via a database, has received before-and-after data that includes 34,000 student

Tamara Lackey

Building the bicycle safety skills of students is a part of many local SRTS programs. Here, a mother is adjusting a child's helmet.

A Prescription for Health in Florida

When Dr. Toni Moody was looking for a prescription for holistic health in Orange County, FL, she looked to increase physical activity by combining SRTS with the U.S. Department of Agriculture's (USDA) Florida Team Nutrition. The result was the Step Up to School Wellness™ Team Nutrition Challenge. In addition, Orange County School District, the 11th largest in the Nation, requires that each school form a Healthy Schools team.

Moody, founder of the nonprofit organization Health Masters Club, reached out to SRTS as the physical activity component of health promotion among schoolchildren. Four schools in the program have increased walking and bicycling.

"A key factor in the success of our program was establishing linkages with the Florida Department of Health and Orange County Health Department to promote Safe Routes to School as a gateway to making communities healthier," says Moody.

With $50,000 in SRTS Federal funds, four schools began a comprehensive educational campaign to promote physical activity among students and obtain parents' support for walking and bicycling to school. Activities include Parent Teacher Association presentations, letters to families from principals, Wellness Wednesdays on Wheels, a 10-day countdown to Walk to School Day, safety lessons for students and options for parents such as park and walk and walking schoolbuses. Second and fourth graders received a ten-lesson safety curriculum. A community partner provided bike helmets for every student who completed a bike safety and helmet-fitting module. Healthy Schools team teachers received minigrants from the Health Masters Club for course and substitute teacher fees to become certified in the Florida Elementary Traffic and Bicycle Safety Education Program.

Crossing guards and student tallies compiled by the NCSRTS help track students who walk or bicycle to school, with Ivey Lane Elementary School showing a 37 percent increase in participation during the program's first year. The number of Orange County schools participating in the Team Nutrition challenge has tripled, according to Moody. But the success of those schools depends on the SRTS component to offer a holistic approach combining exercise with nutrition.

"The mission of the SRTS program complements those of Team Nutrition," says Moody. "It was a good fit to incorporate and promote the healthy eating message along with the importance of physical activity by walking and biking to school."

A mother walks her child home from school. Although the main focus of the SRTS program is on safety and promotion of walking and bicycling, the program also strives to reduce traffic, fuel consumption, and air pollution near primary and middle schools. *Photo: Tamara Lackey.*

tallies with trip-to-school information and 180,000 parent surveys recording their opinions on walking and bicycling to school. FHWA will use information obtained through the national database to determine the effect of SRTS programs on school-based travel habits and safety.

"The national SRTS program is built on a solid foundation of training and data collection," says Lauren Marchetti, NCSRTS director and a task force member. "Although it is too early to evaluate the majority of the funded programs, early successes show increases in walking and bicycling, reduced traffic around schools, and savings in school transportation costs. Some programs are looking at environmental and health outcomes as well."

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To learn more about SRTS and read additional case studies, visit www.saferoutesinfo.org/case_studies. Or contact Rebecca Crowe at rebecca.crowe@dot.gov or 804-775-3381.

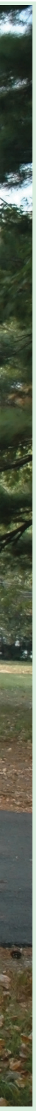
by Carl K. Andersen

The Color Of Safety

An expert symposium cosponsored by FHWA looked at the use of color in conveying safety messages, particularly in highway applications.

(Above) Fluorescent yellow pedestrian crossing signs like this one unambiguously communicate the need for motorists to yield the right-of-way to pedestrians in the crosswalk. *Photo: Jerry Horbert, www.shutterstock.com.*

For thousands of years, humans have used color as a tool to communicate with each other. Today, color permeates daily life. Shoppers rely on color when selecting produce at the supermarket, sports teams use colors to differentiate themselves from opposing teams on the field, and marketers use color to convey information, differentiate products, and move merchandise. In the context of highway transportation, colors shoulder even greater responsibilities, where human lives



are at stake. To wit, red, yellow, and green traffic signals let motorists know when to stop and go at intersections, while orange and black road signs alert drivers to use caution when driving through work zones, among other colors used in various signs to convey information, warnings, and other purposes.

"Color provides a backdrop against which one's imagination can soar," says Michael Halladay, former acting associate administrator for the Federal Highway Administration's (FHWA) Office of Safety. "Or it can serve to bring specific items to your attention."

Halladay delivered the keynote address—"How Safe Are Your Colors?"—at a 1-day expert symposium following the 77th annual meeting of the Inter-Society Color Council (ISCC). At the annual meeting, held in September 2008 in Baltimore, MD, color and its many uses in the modern world took center stage. Founded in 1931, ISCC (www.iscc.org) is a nonprofit professional society that works to disseminate knowledge related to color description and specification. The breadth of the council's interests was evident at the 2008 annual meeting, which featured sessions titled "The reds of love and rage: A note on the risk of eliciting negative emotions" and "What color is that cheese doodle, really? A day in the life of a color specifier."

Following the annual meeting, ISCC and FHWA cohosted a 1-day expert symposium for transportation professionals: "Perception, Measurement, and Application of Safety Colors." Presentations at the symposium shined a light, so to speak, on the connections between color and highway applications—specifically, looking at the role color plays in highway safety. In addition to Halladay's keynote address, three other presenters shared updates on research related to the use of color in the highway community.

Roxane Mukai, traffic manager at the Maryland Transportation Authority, addressed the process of developing the distinctive purple color used for electronic toll collection in the Northeastern United States. Tom Hicks, director of the Office of Traffic and Safety at the Maryland State Highway Administration (SHA), discussed the installation of fluorescent yellow traffic signs at critical locations. And John Molino, Ph.D., senior research psychologist at SAIC, who supports visibility research at FHWA's Turner-Fairbank Highway Research Center (TFHRC), shared initial findings from a study of colored retroreflective sign sheeting under daylight conditions.

Color and Highway Safety

During the keynote address, FHWA's Halladay underscored the inherent power of color to bring things—such as roadway signs, traffic signals, and lane delineation—to the attention of motorists. Color has the capacity to make safety-related messages stand out against the visual clutter of today's roadway environments. FHWA and State and local highway agencies need to understand this power in order to use color effectively, he said.

A critical use of color is to warn of danger or signal the need for

An alliance of toll collection agencies known as the *E-ZPass* IAG selected PMS 259 Purple, shown here on a sign along the I–95 corridor in Maryland, as the color to designate electronic tolling lanes.

John J. Sullivan IV for FHWA

caution, often at distances that preclude other types of signals. An example is the use of red signal lights by maritime, rail, and road authorities to indicate that the observer must yield right-of-way to another party. When combined with an icon such as Mr. Yuk™, the grimace-faced symbol created by the Pittsburgh Poison Center to educate the public about poison prevention, color provides a means of communication to even those who cannot read.

In the world of transportation, where information needs to be communicated successfully over a variety of distances and understood quickly even in the midst of information overload, safety colors need to be unambiguous. Colors selected for use in the highway environment need to be based on a high degree of probability for positive identification by drivers, Halladay said, and restrictions might need to be placed on other uses of specified colors in a given milieu, such as the use of fluorescent yellow-green for advertising along a roadway.

Halladay also discussed the careful balance required between establishing a desired outcome, such as specifying the color requirements for traffic signs, and accounting for the practicality of meeting the requirement. For example, when specifying a safety color for highway traffic signs, standards should allow for a reasonable service life in the field, while providing a high probability of correct identification and appropriate response among motorists. In addition, the requirement should be relatively easy to verify through established measurement procedures, such as ASTM International's standard test method E1349 (the consensus standard for measurement of surface color), so agencies can ensure that critical signs continue to meet the needs of the driving public.

Halladay closed his presentation by laying out three challenges facing color producers, instrument manufacturers, and highway agencies in terms of establishing and maintaining viable standards for safety colors. First, does the context in which the safety color is used, such as the use of fluorescent orange in a work zone for cones and workers' vests, result in a higher degree of proper identification? Even if it does, is it practical or even desirable to modify existing color regions or boxes (the allowable range of a given color used for a specific application) to further minimize the potential for improper color identification? Second, is it possible to develop a measurement procedure that closely matches the human perception of the apparent color of retroreflective materials under various daytime observations? Is such a procedure needed, or would it be more reasonable to work on a simpler measurement procedure that provides more reproducible values? And, finally, is there a point where the use of additional colors in highway traffic signs will result in confusion rather than simplifying the process of information transfer to road users?

These questions, among others, could represent future avenues of research for those studying safety color in general and the use of color in the highway community in particular.

Electronic Tolling Goes Purple

Roxane Mukai's presentation, "Color Me Purple: Or How the *E-ZPass*SM Interagency Group (IAG) Selected the PMS 259 Color Purple," outlined the history of the selection of purple as the designated color for electronic toll collection. The effort began in 1991 when seven toll collection agencies from New Jersey, New York, and Pennsylvania formed an alliance that became known as the *E-ZPass* IAG. The IAG selected the name *E-ZPass* from thousands of potential names and began establishing a distinctive identity for the program, including the design and color of a logo.

In 1991, purple was one of three colors on the *Manual on Uniform Traffic Control Devices*' (MUTCD) reserved color list. Of those three, purple was the least used color and offered the highest contrast level, making it ideal for a new application. A review of available purple color samples from vendors led to selection of Pantone® Matching System® (PMS) 259 Purple for signs identifying electronic toll lanes.

"A key consideration was that all IAG members needed to agree to use the selected color for *E-ZPass* lanes," Mukai said, "providing a high degree of uniformity for signing of electronic toll collection." Today, 24 member agencies in 13 States have joined the IAG and adopted PMS 259 Purple for their electronic tolling signage.

Mukai noted that the IAG has been studying the use of purple pavement markings to further delineate lanes for electronic toll collection. The group will strive to ensure that the appearance of the colored pavement markings closely matches the accepted sign color. She also reported that efforts to produce a purple *E-ZPass* signal light have not been as successful, due to difficulty in obtaining a true purple light and because of small-field tritanopia, a phenomenon that results in a loss of sensitivity to blue light when the signal appears very small. As a result, a purple light might appear red with a blue haze surrounding the signal, potentially causing confusion that could result in erratic behavior as drivers approach toll booths.

On January 2, 2008, FHWA published a Notice of Proposed Amendments to the MUTCD supporting designation of the color purple for use in identifying electronic toll collection. FHWA is analyzing comments on the proposal for the next edition of the MUTCD. Rulemaking could be completed by late 2009. For more information, visit http://mutcd.fhwa.dot.gov/res-notices.htm.

Fluorescent Yellow On Traffic Signs

During a presentation titled "Implementing Fluorescent Yellow on Traffic Signs at Critical Locations," Tom Hicks of Maryland SHA discussed the regulation of traffic control devices (TCDs), which the MUTCD defines as "all signs, signals, markings, and other devices used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, or bikeway by authority of a public agency having jurisdiction." He stressed that TCDs should fill a need, command attention, convey a clear and simple meaning, command respect from road users, and provide adequate time for a proper response. With these issues in mind, SHA conducted evaluations on the use of fluorescent yellow traffic warning signs.

Previous human factors testing indicated that, compared to standard yellow, fluorescent yellow signs would improve detection and recognition under a variety of environmental conditions. As reported

These photos demonstrate the improvement in visibility, during daytime and at night, made possible by using fluorescent yellow versus standard yellow signs. During the day and at night the fluorescent yellow signs (bottom) appear brighter than the standard yellow signs (top). *Photos: 3M.*

in a 2001 study by researchers at North Carolina State University, *The Effect of Fluorescent Yellow Warning Signs at Hazardous Locations* (PB2001-107693), not only did recognition improve during daytime (when fluorescence assists in detection against high levels of visual clutter in the roadside environment), but also at dawn and dusk, and during fog and rain. The reason for this improvement in performance is that fluorescent signs provide higher luminance than their standard counterparts, while retaining highly saturated colors. Hicks explained that the luminance of the fluorescent yellow signs is as much as twice that of standard yellow signs during daytime and anywhere from two to three times as great at night.

Based on this earlier study, SHA researchers in December 2001 decided to evaluate fluorescent yellow signs on Maryland highways. As part of the evaluation, the researchers evaluated stopping behavior at a site with limited sight distance to the STOP sign along one approach. The researchers conducted an evaluation of free-flowing traffic before and after installation of fluorescent yellow STOP AHEAD signs and found that nonstopping behavior decreased from approximately 10 percent of traffic (on the occluded, or obstructed, leg) to approximately 3 percent. In addition, the average distance at which drivers initiated braking increased significantly.

Subsequent to the success of the experimental applications, the researchers determined that fluorescent yellow signs provide equivalent durability in retention of both color and retroreflectivity. Over time, SHA amended its policy on the use of fluorescent yellow signs, ultimately resulting in a final policy decision in 2004. The current policy states that fluorescent yellow will be used on all road systems on all warning signs, with the exception of school/pedestrian warning signs and freeway incident traffic management signs, which will use the reserved fluorescent yellow-green and fluorescent pink colors, respectively.

The 2003 MUTCD does not specifically address fluorescent yellow, but in 1999 FHWA made an official interpretation allowing its use in highway signs. The addition of fluorescent yellow to the section on sign colors is among the proposed amendments for the next edition of the MUTCD.

Testing Sign Retroreflectivity

John Molino's presentation, "A Comparison of Colored Retroreflective Sign Sheeting Under Daylight Conditions: Perception Versus Measurement," briefed symposium attendees on initial results from an ongoing FHWA study. He explained that daylight measurements of the color of retroreflective materials used for roadway signs are generally more variable than measurements of nonretroreflective materials. Retroreflective surfaces have spherical or prismatic reflectors that direct light back in nonuniform

John Molino, SAIC

These people are participating in an FHWA study designed to assess the apparent daytime color of assorted retroreflective sheeting samples.

ways. These materials are designed to reflect a maximum amount of light from the headlights of a vehicle back to the eyes of a driver. The chromaticity (quality of color) of the material under daylight viewing conditions is generally a secondary concern, Molino said.

The reproducibility of color measurements of retroreflective materials during daylight hours in the field shows considerable variability. Slight variations between colorimeters (instruments used to measure color) and field spectral photometers (instruments used to measure luminance or brightness) can result in significant differences in measured color. Furthermore, previous FHWA research has shown that field measurements of chromaticity do not correspond to perceived color judgments made by human observers.

"Understanding and reducing these inconsistencies is important to FHWA for defining the size and shape of the color boxes [the coordinates in color space that define the boundaries of acceptable colors] used to specify colors for roadway signs," Molino said, especially as these color boxes are incorporated into Federal regulations (23 CFR Part 665, 2002, Color Specifications for Retroreflective Sign and Pavement Marking Materials).

In this FHWA study, researchers measured the color and luminance of retroreflective sign materials under laboratory and field conditions. Then they compared the instrument measurements with the perceptual judgments of color and brightness made by human observers in the field. Next, the researchers employed a percentage estimation technique for the perceptual rating of hue and saturation, along with a similar perceptual rating procedure for brightness. The researchers determined the hue, saturation, and brightness for four types of retroreflective sheeting materials and one diffuse plaque, four quadrants of the color box (as described in the Federal regulations), and six colors specified for use in roadway signage. Altogether they evaluated 120 color and material combinations (five types of sign materials x four quadrants x six colors).

Research participants sat outdoors under a shade tent on a closed road and viewed 7.5- by 7.5-inch (19- by 19-centimeter) test samples at a distance of about 100 feet (30 meters). After viewing a sample for 10 seconds, participants were asked to respond with hue, saturation, and brightness ratings, using a rating scale ranging 0 to 100 percent for all three judgments. A total of 17 participants rated all 120 samples twice a day for 4 days. To supplement the test participants' subjective brightness ratings, the research team obtained separate subjective brightness rankings for one quadrant of the yellow and red colors of the five materials.

Then the researchers plotted the hue scaling data on uniform appearance diagrams (UADs). These diagrams represent a two-dimensional perceptual color space based on red-green and blue-yellow dimensions. The UADs are based upon the opponent process theory of human vision, where red and green operate as an antagonistic color pair, designated as the *a* dimension, and blue and yellow operate as a second antagonistic color pair, designated as the *b* dimension. These two dimensions are used to establish the coordinate system for the UADs for perceived color. A third dimension, designated the *L* dimension, is composed of black and white and is achromatic (devoid of color). This third dimension is associated with the luminance, or brightness, of the stimulus. For objective instrument measurements, the corresponding three dimensions (*L*, *a*, and *b*) can be combined into a three-dimensional color space, referred to as a "Lab," or "LAB," space. A widely used version of this formulation, which scientifically describes how the average human eye sees color, is known as CIELAB, where the CIE stands for Commission Internationale de l'Éclairage.

After plotting the UADs, the researchers compared these perceptual hue and saturation data to CIELAB plots produced from the instrument chromaticity measurements made in the laboratory and in the field to determine how well the instrument color measurements corresponded to perceived color appearance. The researchers also compared the instrument measurements to determine how well the laboratory measurements corresponded to the field measurements. Similarly, the researchers compared the instrument-measured luminance determinations from the various sample stimuli in the laboratory and in the field with each other, and with the brightness ratings reported by the study participants.

The study used sheeting samples specified in the ASTM standard specification D4956-07. On average, the research team found that participants rated sheeting types VIII (super-high-intensity retroreflective sheeting having highest retroreflectivity characteristics at long and medium road distances) and IX (very-high-intensity retroreflective sheeting having highest retroreflectivity characteristics at short road distances), and proposed type XI (which uses a new, highly efficient optical design for reflecting light) closer to the laboratory measurements than sheeting type III (high-intensity retroreflective sheeting that is typically encapsulated glass-bead retroreflective material) and diffuse plaque (no retroreflective properties). In the supplemental brightness determinations, participants ranked sheeting types VIII, IX, and proposed XI higher than sheeting type III for both red and yellow colors. Diffuse plaque received the highest brightness rankings of all five materials for both colors.

Overall, the participants' responses aligned well with the instrument measurements. The responses actually indicated a greater perceptual separation between hues, especially those for the red and orange color boxes, than the measurements revealed. That is, the human observers seemed more sensitive to hue differences than the instruments. However, study participants tended to perceive the colors to be less saturated, on average, when compared to instrument measurements, and detected little difference in the saturation of the four quadrants for yellow and orange. According to Molino, this implies that, within certain limits, the fading of yellow and orange signs, although not desirable, might not pose as significant a problem as physical measurements might indicate.

A comparison of the luminance measured in the field with the participants' ratings of brightness indicated that people are less sensitive to differences in the luminance of signs that are relatively bright (as is typical for white and yellow backgrounds) than to differences in the luminance of relatively dark signs (especially blue). The results indicate that for people with normal color vision, the probability of improper color recognition of traffic signs, at least for the colors evaluated, appears to be very low. However, the subtle differences between instrument measurements and human perception, and the relative lack of human sensitivity to differences in color saturation and sign luminance, indicate a possibility that existing measurement procedures can fail to properly account for how the driving public views individual signs.

Ultimately, the researchers found that the red versus orange sign materials and, to some extent, the orange versus yellow sign materials were more difficult for observers to discriminate. Although not likely to be a source of confusion with the present definition of acceptable colors, Molino says, care needs to be taken when considering modifications to color boxes in these color regions. The final report will be available by fall 2009 at www.tfhrc.gov/safety/index.htm.

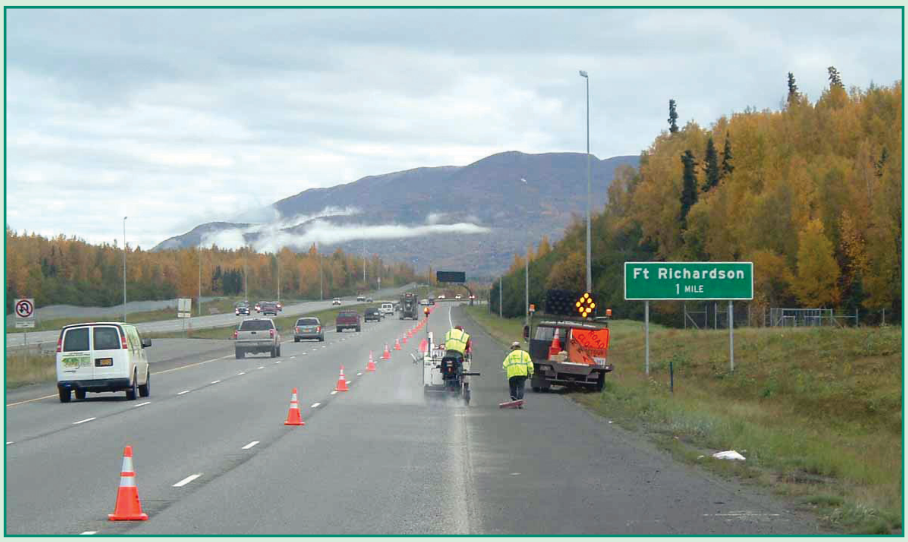
Ongoing Color Studies

Colored materials used in highway traffic signs and pavement markings need to provide reasonable service life under difficult environmental conditions, and, increasingly, contain limited or no toxic chemicals. As directed by Congress in Section 1907 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, FHWA is conducting demonstration projects in Alaska and Tennessee to study the safety and environmental impacts and cost effectiveness of different pavement marking systems and the effect of State bidding and procurement processes on the quality of pavement marking materials employed in highway projects. The projects will include an evaluation of the impacts and effectiveness of advanced acrylic water-borne pavement markings and lead-free thermoplastic yellow paint, which could become environmental friendly alternatives to existing paint systems that contain toxic chemicals.

The presentations shared during the ISCC expert symposium underscore the importance of the highway safety community having an understanding of perceptual responses to color and the process of specifying and measuring color. When it comes to color in the roadway environment, one might go so far as to say, "Safety is in the eye of the beholder."

Carl K. Andersen is the roadway team leader in the Office of Safety Research and Development at TFHRC and also manages the Arens Photometric and Visibility Laboratory. He holds a master's degree in physics from the Naval Postgraduate School, Monterey.

For more information, visit www.tfhrc.gov/about/pvl.htm or contact Carl Andersen at 202-493-3366 or carl.andersen@fhwa.dot.gov.



Texas Transportation Institute

These workers are participating in a pavement marking demonstration project on a highway in Alaska. The image captures three aspects of safety color application: the yellow warning lights on the cab of the truck, the fluorescent orange cones to delineate the work zone, and the fluorescent yellow-green safety vests worn by the workers.

Reconstructing Snoqualmie Pass

by Amanda Sullivan and Amy Danberg

WSDOT takes on current challenges and anticipates new ones in a project to improve the I–90 corridor over the Cascades.

Interstate 90 (I–90), which traverses the northern United States from Seattle, WA, to Boston, MA, is the main east-west transportation corridor across Washington State. The highway connects Puget Sound's deep-water ports, large population centers, and retail and service businesses with agricultural and recreational areas in eastern Washington. The highway facilitates uninterrupted movement of people and freight, which is essential to the State's economic vitality, over the Cascade Mountains via Snoqualmie Pass.

Before 1930, Snoqualmie Pass would close for approximately 6 months out of the year due to severe weather and unsafe driving conditions. Since the 1930s, the Washington State Department of Transportation (WSDOT) began a concerted effort to keep the pass open year-round. Despite multiple improvement projects to the interstate, avalanches, rock slides, and

The I–90 Snoqualmie Pass East Project is in the heart of the steep and snowy Cascade Mountains of central Washington.

extreme weather continued to require closing the pass for an average of 120 hours per year.

In 2005, recognizing the growing need for a safe and efficient roadway, as well as year-round travel, the Washington State Legislature secured funding for a reconstruction project known as the I–90 Snoqualmie Pass East Project (I–90 Project). Through the project, WSDOT will improve the safety and reliability of a 15-mile (24-kilometer) stretch of I–90 east of Snoqualmie Pass. Specifically, the department will widen the existing four-lane interstate to six lanes to account for recent and predicted increases in traffic; fix structural deficiencies, such as replacing worn-out pavement and straightening sharp curves; and reconnect habitats across I–90 to minimize wildlife-vehicle collisions. Other critical components of the project include reducing the risk of rock and debris falling onto the interstate from unstable slopes, reducing avalanche risks to the traveling public, and minimizing road closures required for avalanche control work.

To put the wheels in motion, the Washington State Legislature provided $387 million as part of the State's 2005 Transportation Partnership Program. The underlying source of funding was a new voter-approved increase in the gas tax of 9.5 cents per gallon. The legislature designated supplemental funding to cover escalating raw material costs and inflation over the last 4 years, bringing total project funding to $595 million (as of May 2009).

The funding enables design and construction of a 5-mile (8-kilometer) project from the community of Hyak to Keechelus Dam, and leaves an unfunded 10-mile (16-kilometer) section from the dam to the town of Easton. Construction of the Hyak to Keechelus Dam project begins in summer 2009 with the building of a long-term detour bridge and excavation of materials from the Keechelus Lake reservoir, which mitigates for the construction's future impact on water storage.

"The groundbreaking for the Hyak to Keechelus Dam project is exciting for WSDOT and our project partners," says I–90 Project Director Randy Giles. "The milestone represents 10 years of partnerships, planning, studies, and designing for a project that achieves the delicate balance of integrating transportation objectives with ecological needs."

(Left) WSDOT will improve this stretch of I–90 along Keechelus Lake as it preserves the vital commercial route across Washington State and over Snoqualmie Pass.

All photos courtesy of WSDOT.

Identifying a Preferred Alternative

The topography, geology, weather, ecological connectivity commitments, and traffic constraints in the I–90 Project corridor presented a variety of engineering challenges. The topography of the Central Cascades is mountainous peaks and valleys. For the first 6 miles (9.7 kilometers) of the project area, I–90 runs along a narrow corridor between steep mountain slopes and the shores of Keechelus Lake, a deep agricultural reservoir. The slopes contain volcanic bedrock at varying depths that are subject to deep fissures and cracks with weakened slip planes from which rock could break off and slide. Combined with high annual precipitation and freeze-thaw conditions, the slopes are susceptible to landslides, debris flows, and avalanches.

The last major road construction on I–90 Snoqualmie Pass began in the 1950s, when President Dwight D. Eisenhower signed the Federal-Aid Highway Act of 1956, which started the construction of interstate highways. Construction was completed in the 1970s. Since then the State's transportation needs and economy have changed.

Today, daily traffic on Snoqualmie Pass averages about 27,000 vehicles, typically 22,400 passenger vehicles and 4,600 freight vehicles. Traffic volumes can rise to more than 58,000 vehicles on weekends and holidays. According to WSDOT, travel across Snoqualmie Pass is growing at an annual rate of 2.1 percent, with 51,000 vehicles projected to use I–90 daily by 2028.

Identifying the preferred alternative for the roadway design and alignment involved collaboration with resource agencies, technical investigations, engineering reviews, and public participation. Since 1999, WSDOT and the Federal Highway Administration (FHWA) have worked with dozens of government agencies and nongovernmental organizations to develop and consider a range of potential solutions to meet project needs and mitigate impacts on motorists, the economy, and the environment.

Heavy snow stalls freight movement through Snoqualmie Pass on the existing highway, as evidenced by this bumper-to-bumper queue of trucks.

WSDOT created a multiagency interdisciplinary team as an advisory group to recommend a preferred alternative that incorporated relevant science and the concerns of various stakeholders. That team led to creation of a mitigation development team—a technical advisory subcommittee of hydrologists, biologists, and engineers—to identify sensitive environmental areas and develop criteria for investments in ecological connectivity. In addition to these teams, WSDOT formed technical committees to assist in permitting and planning final designs for wetlands mitigation, wildlife monitoring, and stormwater treatment.

"Although we've accomplished remarkable permitting milestones due to our stellar design team and partnerships with permitting agencies, keeping up with the forthcoming construction phases of the project will be a challenge," says Mark Reynolds, I–90 Project permitting coordinator at WSDOT. "To maintain our successful permitting process, our design and permitting agencies will need to identify challenges early, communicate solutions to those challenges, and deliver on our commitments."

WSDOT formed partnerships with university researchers and conservation groups to help establish citizen awareness, initiate wildlife monitoring, and target land acquisitions. The agency also formed relationships with transportation-related organizations, associations, and businesses to gain insight into the requirements of interstate users. The Washington State Good Roads & Transportation Association and local and national freight companies, for example, identified concerns regarding delivery disruptions during construction. WSDOT listened to these concerns and committed to keeping two lanes of travel open in each direction through the construction zone during peak travel times to limit traffic delays over I–90 Snoqualmie Pass. WSDOT also committed to providing freight organizations with construction information in advance, such as e-mail notices and other tools, so they can plan their delivery times accordingly.

WSDOT and FHWA released a draft environmental impact statement (EIS) in 2005, highlighting six design alternatives for the I–90 Project. The agencies held public hearings during the 45-day comment period and received comments from more than 3,300 individuals, groups, and agencies.

In 2006, WSDOT began multiyear preconstruction activities, such as design, geotechnical drilling, ground water monitoring, surveying, right-of-way acquisition, final analysis under the National Environmental Policy Act (NEPA), and permitting. WSDOT also developed its Wildlife Monitoring Plan in cooperation with the Wildlife Monitoring Technical Committee and the Western Transportation Institute at Montana State University.

WSDOT and FHWA released the final EIS identifying the preferred alternative in August 2008. The preferred alternative, the Keechelus Lake alignment, follows the existing roadway alignment because this approach involves less construction risk, costs less than the tunnel alternatives, and will result in fewer impacts on the environment. In October 2008, FHWA issued a record of decision (ROD) based on the final EIS.

"The ROD was a significant milestone representing many years of working with communities and building a coalition of environmental interests, business groups, and project advocates around a plan to improve Snoqualmie Pass so that it is safer for drivers and more dependable for our economy," says WSDOT South Central Regional Administrator Don Whitehouse. "The overwhelming support for this project shows the importance I–90 plays in connecting our State."

Construction under the first contract of the Hyak to Keechelus Dam project began in summer 2009. In October 2009, WSDOT will advertise the next contract to begin replacing the old lanes and adding a new lane in each direction, rebuilding bridges, and extending chain-up/off areas along the first 2 miles (3.2 kilometers) of the project. (Chain-up/off areas are safe areas for motorists to pull off the interstate to put on and take off tire chains. WSDOT often requires motorists to put chains on their vehicles for maximum traction.) Construction on this phase will begin in summer 2010. By fall 2010, WSDOT will advertise the third contract, which continues adding new lanes in each direction, replacing the snowshed (a concrete shed used to provide permanent protection from avalanches and other falling debris to travelers passing through Snoqualmie Pass), addressing unstable slopes, building new bridges, and constructing new chain-up/off areas on the project's next 2 miles (3.2 kilometers). That contract is scheduled to begin construction in 2011.

Geotechnical Complexities

To move design plans forward, WSDOT gathered geotechnical data from extensive drilling operations on the mountain slopes and

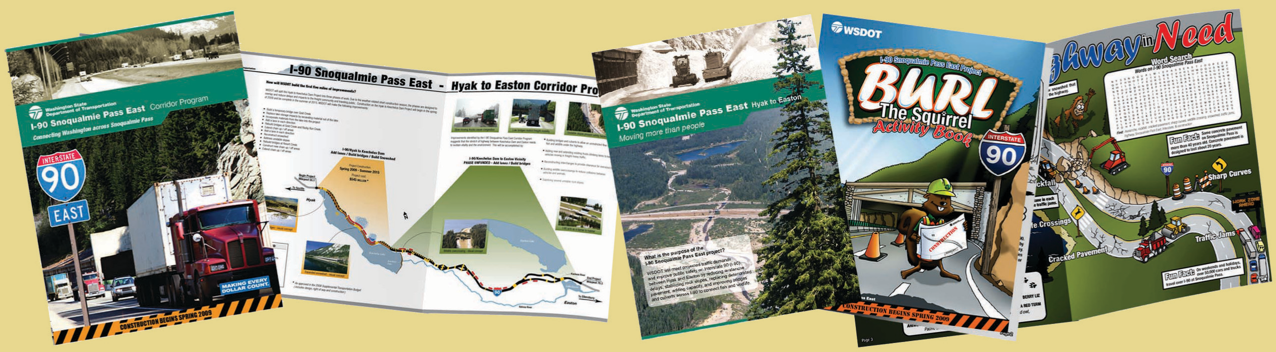
Communications Strategies for the Snoqualmie Project

Because of the rural location of the I–90 Snoqualmie Pass East Project, WSDOT cast a broad net with its education and information campaigns. The goal was to earn and maintain statewide support from the public and interested parties. The department's communications strategies feature plain language and reader-friendly writing; reach out to audiences directly through WSDOT's I–90 Project Web site; and present the project visually for ease of understanding.

"We strive to be the first and best source of information about the agency, whether the news is good or bad," says Assistant Regional Administrator of Project Development Brian White, with the WSDOT South Central Region. "We provide timely and transparent communications. We are proactive in anticipating the public's needs and work to provide useful information."

Another communications strategy is to present the project visually. Because of the remote location and complexity of the I–90 Project, the department created a three-dimensional fly-through video of the proposed design concept.

These innovative communications strategies have generated hundreds of articles in print and broadcast media and contributed to more than 50 presentations at fairs, festivals, and other events across the State in 2008. The I–90 Project has garnered national and international attention as well, such as being the focus of a national conference of transportation planners called the Southern Rockies Ecosystem Project, and hosting a guided project tour for a delegate from the Taiwan Environmental Protection Administration. Overall, the communications program appears to



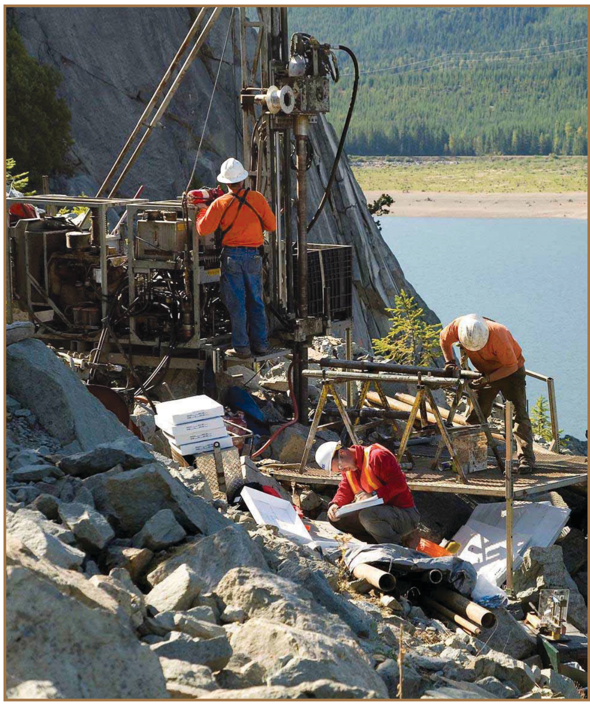
As part of the public information campaign for the I–90 Snoqualmie Pass East Project, WSDOT developed a series of reader-friendly materials including an informational brochure (left), an environmental brochure (center), and the "Burl the Squirrel" activity book for children (right).

WSDOT integrated the strategy of using plain language into all public information materials and adopted it as a business practice for all disciplines. The department developed engineering- and environment-focused public information handouts, and an award-winning children's activity book featuring Burl the Squirrel, to help reach and educate diverse audiences, from children to elected officials.

WSDOT used the I–90 Project Web site as a primary way to reach audiences with information unfiltered by other sources. An online project library houses all public information materials, downloadable for use at any time.

have resulted in a high degree of awareness for the project and contributed to a broadly supportive public and political constituency. For example, WSDOT already has won multiple public affairs awards for the project, including the Transportation Research Board award for "Communicating with John and Jane Public" and the National Transportation Public Affairs Workshop award for illustration.

To view public outreach materials from the I–90 Project, visit the project's Web site at www.wsdot.wa.gov/Projects/I90/SnoqualmiePassEast.



WSDOT and contractor crews drill and log core samples along a cliff in the project area to obtain information on the slope's stability.

in the lakebed. Findings indicated that certain areas of the project contained stable rock and favorable sediment, while others contained soft, fragile rock and liquefiable soil. Based on this information, WSDOT design engineers had to create plans for improving ground conditions for foundations, elevating the road profile to accommodate unstable slopes, and stabilizing rock slope cuts before and during construction.

"Liquefiable soil conditions result in global instability of structure foundations," says Scott Golbek, a WSDOT engineer with the I–90 Project. "In order to achieve acceptable seismic conditions for the foundations, WSDOT first has to improve the liquefaction-susceptible soils beneath the approach fills and abutments of the multispan Gold Creek bridges."

Soil improvements are slated to begin in 2010. Geotechnical engineers propose to improve liquefiable soils with compaction grouting. A very viscous (low-mobility), aggregate grout will be pumped in stages, starting up to 50 feet (15 meters) deep in places and working toward the ground surface. The grout will form a column of bulbs, which displace and densify the surrounding soils. The grout columns will be constructed on a grid pattern designed to suit load, soil, and seismic performance. Once complete, the grout columns will reduce foundation settlement, mitigate liquefaction potential, improve shear resistance, and increase bearing capacity.

WSDOT's investments in preliminary geotechnical work "will reduce the risk of encountering unexpected rock and soil conditions, which could lead to cost overruns during the construction phase," Golbek says.

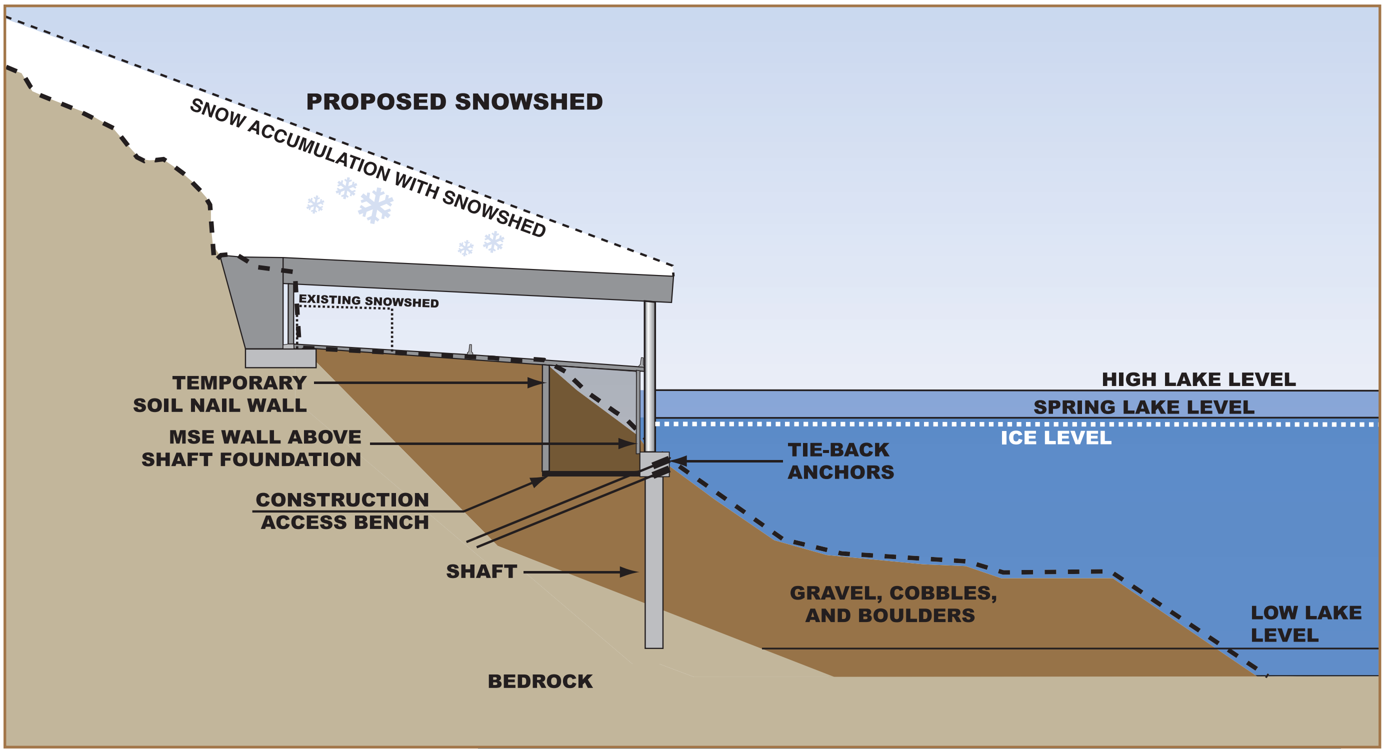
Widening in a Narrow Corridor

A major purpose of the I–90 Project is to increase capacity by adding a lane in each direction. To realign and widen the interstate to six lanes, WSDOT engineers and contractors had to consider the effects of making additional rock cuts into zones of previously unstable fracture planes or weak rock present along the mountainous corridor.

"Rock conditions in volcanic terrains are highly variable and defy accurate characterization," says Norm Norrish, principal of Wyllie & Norrish Rock Engineers Inc., an engineering contractor involved in the project. "The new alignment of the interstate, particularly where slopes attain vertical heights in excess of 120 feet [36 meters], could be in jeopardy if faults; flow boundaries; ash layers; weak rock masses; thick, marginally stable soils; or other unfavorable geologic conditions are present."

To identify terrain conditions and design the realignment, WSDOT, the contractor, and geologists conducted state-of-the-art field investigations that included geotechnical drilling, downhole surveys, structural geologic mapping, and installation of instrumentation to measure ground water pressures and slope displacements. The team coupled data from these activities with laboratory testing, input the information into detailed slope stability analyses,

This design visualization shows a new snowshed (left), slated for construction in 2011, with an avalanche tumbling over it. The structure covers the lanes in both directions, helping protect motorists traveling through Snoqualmie Pass from experiencing the brunt of an avalanche. The original snowshed (right) protected only the travel lanes closest to the mountainside.



This diagram demonstrates the complexities of building a snowshed adjacent to both a mountain and a lake.

and used historical performance of slopes to "calibrate" new designs wherever possible.

Field investigation findings identified a series of linear depressions across a troublesome slope aptly named Slide Curve. The fissure was nearly 4 feet (1.2 meters) across and more than 30 feet (9 meters) deep in places, indicating displacement of a large block of bedrock. Potential instability of these localized zones of poor quality rock mass required WSDOT design engineers to raise the westbound roadway grade up to 50 feet (15 meters) above the previously designed grade. This alteration will provide the dual benefits of reducing the size and extent required to cut slopes, while buttressing the existing, marginally stable slopes.

WSDOT and its consultants have identified a number of other potentially unstable slopes along the project corridor that will require stabilization as the rock cuts are excavated. Crews will stabilize these slopes with grouted steel bars designed according to the structural geology and height of each rock cut.

Operating Efficiently And Reliably

The project also seeks to reduce avalanche risks to the traveling public and minimize road closures required for avalanche control work. WSDOT will begin working toward this objective in summer 2011 with construction of a 1,100-foot (335-meter)-long concrete snowshed and avalanche fencing.

Five natural avalanche chutes regularly funnel snow onto the roadway in the project corridor. The existing snowshed, built in 1950, only protects the westbound lanes from the two most active of the five chutes, leaving portions of the interstate vulnerable to snow from natural avalanches and avalanche control measures. WSDOT must undertake extensive winter maintenance to keep this portion of the pass open.

The new snowshed will protect the entire width of interstate from four of the avalanche chutes with an enlarged ditch providing a catchment area for the remaining minor chute. Avalanche fencing, like that used extensively in the Alps, will protect the interstate from a smaller avalanche zone located at Slide Curve.

"The closures on I–90 Snoqualmie Pass can vary from year to year but average over 60 hours per year within the project area alone," says Giles. "When the snowshed is complete, we hope to reduce those closures by 70 percent."

WSDOT will construct the snowshed using standard bridge design techniques. A reinforced concrete wall on the mountainside and a pier cap over columns on the lakeside will support a concrete roof over precast girders.

"In addition to designing the snowshed around the area's unfavorable soil and rock slope conditions, weather limitations, and construction access, maintaining existing traffic levels during the construction phase will be challenging," Golbek says.

The Central Cascades experience extreme temperature fluctuations, severe seasonal rains, and heavy snowfalls that limit the construction season to about 7 months a year. WSDOT estimates that building the snowshed will require five seasons to complete, and engineers have devised a detailed construction phasing plan that enables crews to build the new snowshed around the existing one to protect the interstate. In the fourth year, WSDOT will remove the old snowshed and complete the new snowshed's roof.

Another variable in construction phasing is Keechelus Lake's water level, which varies by some 70 feet (21.3 meters) depending on irrigation

This design visualization shows the new Gold Creek Bridges, which will allow wildlife to cross safely under the interstate and will improve stream channel migration and fish passage. Fences will guide wildlife safely under the bridges.

needs and precipitation. Therefore, construction activities such as installing vertical anchors and setting precast girders will follow the receding lake water levels downslope throughout the summer and fall of each construction year. Keechelus Lake is one of several irrigation reservoirs in a system where water rights are overallocated, so WSDOT must be careful not to affect lake storage levels. WSDOT has a no-net-loss commitment with the U.S. Department of the Interior's Bureau of Reclamation, for which WSDOT agreed to excavate materials from the lake to allow for expansion of I–90. The agency will recycle the excavated materials, mostly gravel and soil, back into various phases of the project.

Staging construction and keeping traffic moving through the narrow project work zone is another challenge. To mitigate effects on the traveling public, WSDOT has committed to keep two lanes open in each direction during peak travel times, with single-lane closures during offpeak times. The department will employ an extensive communications program to inform the public about construction, using its Web site, traffic cameras, highway advisory radio, variable message signs, and phone hotline. Further, WSDOT created a detailed traffic management plan to establish detours for the public and emergency vehicles during construction.

Environmental Complexities

Improving ecological connectivity (defined as continuity between neighboring habitats and ecosystems and their flora and fauna) and preserving habitat also are critical components of the I–90 Project. The large areas of protected Federal, State, and conservation lands north and south of the project corridor support a broad range of habitats. I–90 itself severely limits wildlife movement and forms a physical barrier between upstream and downstream aquatic environments. Culverts and narrow bridges limit movement of aquatic species, and in many cases the highway embankment has filled in habitat that once made up channels, floodplains, and associated wetlands. In addition, wildlife that cross the interstate at grade represent a safety concern to the traveling public.

To establish ecological objectives during the NEPA and State Environmental Policy Act scoping phase of the project, WSDOT partnered with the U.S. Forest Service and conservation groups. These entities already were working to acquire conservation land through land exchanges and purchasing much of the remaining private property along the I–90 corridor to preserve the delicate ecosystems of the Central Cascades.

To ensure that the I–90 Project's objectives align with the actions of the other groups, the project's mitigation development team worked with WSDOT design engineers and environmental planners to advise the interdisciplinary team of locations along the project corridor that were suitable for investments in infrastructure and restoration activities. The mitigation development team's strategy considered landscape-, watershed-, and habitat-specific variables to identify connectivity emphasis areas. The teams used these recommendations to develop a comprehensive list of connectivity objectives and performance standards for evaluation of design options.

WSDOT worked with many agencies that manage land and resources in the project area through small, focused technical advisory teams that helped the department gather data on target species, habitat needs, and project constraints. WSDOT then used the data to help evaluate bridge and culvert designs that improve wildlife connections, stream channel migration, fish passage, and habitat. The department plans to begin building these improvements in spring 2010. The engineering team also is testing various prototypes of wildlife exclusionary fencing to develop a design that will withstand winter weather conditions and maintenance operations, and direct wildlife to crossing structures that enable them to pass safely under or over the highway.

"The I–90 Project's overarching wildlife connectivity objectives are to improve motorists' safety by minimizing the risk of wildlife-vehicle collisions, and to improve the ecological permeability of the highway for fish and wildlife," says Jason Smith, an environmental manager with the WSDOT South Central Region. "Objectives will be accomplished, in part, by installing crossing structures and fencing that will allow wildlife to safely cross over and under the interstate, and by constructing bridges and culverts that help restore hydrologic processes and fish passage through the interstate."

As WSDOT constructs new bridges and culverts, it will restore wetlands, stream channels, and riparian areas at the connectivity emphasis areas, which includes forested habitat, buffer improvements, and highway slope revegetation. WSDOT also acquired a 265-acre (170-hectare) property for habitat preservation in the Gold Creek valley that contains wetlands, riparian areas, and mature forest, including potential habitat for northern spotted owls, marbled murrelets (small birds), and bull trout, all listed for protection under the Federal Endangered Species Act. WSDOT committed to preserve this property in perpetuity.

To measure the effectiveness of the investments in ecological connectivity and evaluate fulfillment of the objectives, WSDOT partnered with the Forest Service, the Western Transportation Institute, and Central Washington University on a long-term, multiphased monitoring program that will yield scientific data regarding pre- and postconstruction wildlife activity.

Preconstruction wildlife monitoring objectives include quantifying existing rates at which various species cross the highway, assessing the rate of wildlife-vehicle collisions, and surveying the project area to evaluate species occupancy and distribution. Monitoring efforts have been underway since spring 2008 and include using remote cameras to assess wildlife use of existing culverts and underpasses, using snow tracking to document crossing rates, and employing noninvasive survey methods and live capture to evaluate the distribution of various target species.

"The program addresses not only large, wide-ranging species, but also lower mobility species such as amphibians, small mammals, and fish," says Smith. "Further, the monitoring program emphasizes a multitiered approach that will permit exploration of basic performance standards, as well as larger scale questions of wildlife connectivity. The systematic collection of pre- and postconstruction wildlife data will help with the design of highway improvements in later stages of the project and on projects occurring elsewhere."

The Future of I–90

The first 5 miles (8 kilometers) of the I–90 Project from Hyak to Keechelus Dam is slated for completion in 2015. WSDOT will continue roadway improvements on the remaining 10 miles (16.1 kilometers) of the project area from Keechelus Dam to Easton as funding becomes available. Construction of the remaining portion of the I–90 Project is estimated to cost between \$700 million and \$800 million, in 2009 dollars, and could require 7–15 years to complete.

In the meantime, WSDOT will work with its partners and use open communication with the public to ensure the continued viability of I–90 as a primary statewide and national corridor. "WSDOT, through the I–90 Project, will keep Washington moving by operating efficiently, adding capacity strategically, and managing demand," says Brian White, assistant regional administrator of project development for WSDOT's South Central Region.

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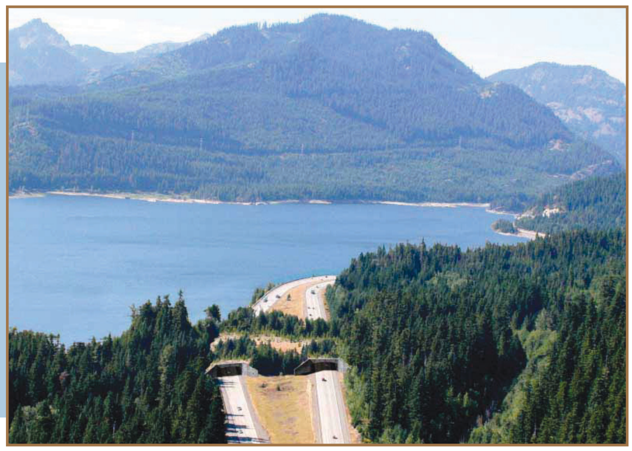


This design visualization shows a proposed wildlife overcrossing at Keechelus Dam. This location is outside the currently funded 5-mile (8-kilometer) portion of the I–90 Project.

by Ramanujan Jagannathan, Warren Hughes, and Joe G. Bared

A New Left Turn

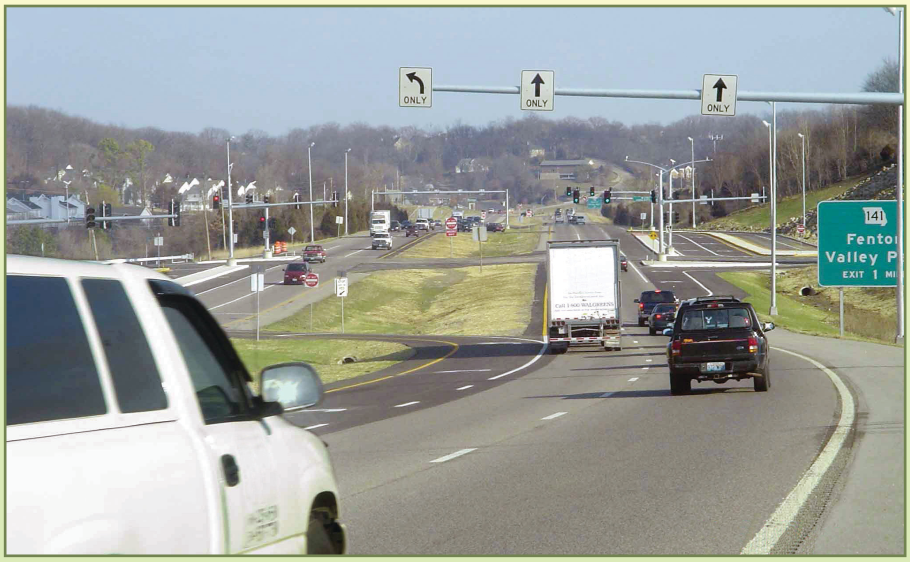
These preliminary observations discuss the operational benefits and potential safety of displaced left-turn intersections.

This aerial view was taken approximately 12 months after this displaced left-turn (DLT) intersection in Baton Rouge, LA, opened to traffic. *Photo: Charles Breard Aerial Photography, Baton Rouge, LA.*

Navigating intersections is one of the most complex actions that drivers perform. In 2008, 37,261 fatalities took place on the Nation's roadways. According to the National Highway Traffic Safety Administration's (NHTSA) *Traffic Safety Facts 2006,* about 23 percent of the total fatal crashes in 2006 occurred at intersections, and more than half of the combined number of fatal and injury crashes were intersection-related. The annual cost to society for intersection-related crashes is estimated to be approximately $40 billion. Despite improved design and traffic engineering measures, the annual human toll from motor vehicle crashes at or near intersections has not changed much in a quarter century, NHTSA notes.

In addition to the safety impacts, conventional intersections can impose costs on the public in terms of congestion and travel delay. Traffic congestion at signalized intersections is frequently worsened when left-turn phases are introduced. By eliminating left turns at the main intersection, transportation agencies could provide more green time to vehicles moving through the intersection instead of losing time for left turns that conflict with through traffic. The elimination of left turns using an approach

This photograph shows vehicles approaching a DLT and mainline intersection on Route 30 eastbound in St. Louis, MO.



Steven Scott, MoDOT

known as a displaced left-turn lane (DLT) has been implemented primarily for congestion relief but could have safety benefits.

The DLT intersection, also known as a continuous flow intersection (CFI), eliminates potential conflicts between left-turning vehicles and oncoming traffic by adding a left-turn bay to the left of oncoming traffic prior to the main intersection. Vehicles access the left-turn bay upstream of the main signalized intersection and cross over the median and the opposing through segment and thereby eliminate left-turn crossing within the main intersection.

Transportation agencies have implemented DLTs to reduce congestion at several locations in the United States. The first DLT was built in Long Island, NY, in 1996. Another, built in Maryland in 2000, has a DLT lane only on one approach; it has reduced the average delay per vehicle through the intersection by about 60 percent of the major through movement and a comparable reduction on the major left-turn movement, according to simulated results from the Maryland State Highway Administration.

A 2004 traffic simulation analysis published by the Transportation Research Board, *Design and Operational Performance of Crossover Displaced Left-Turn Intersections,* estimated that DLTs helped reduce average delay 48 to 85 percent and cut queue lengths 62 to 88 percent, compared to conventional intersections. Researchers are still evaluating the effect of this design on intersection operations and safety, but many State departments of transportation are considering DLTs, based on these findings alone.

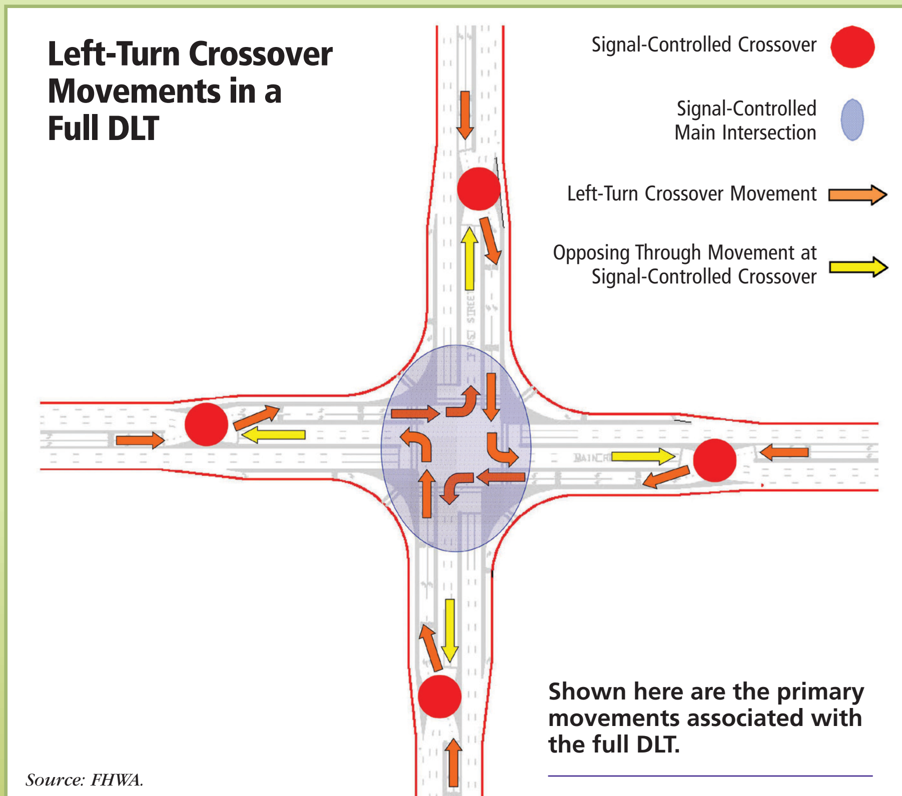
DLTs: What They Look Like

The main feature of this alternative intersection is relocation of the left-turn movement on an approach to the near side of the opposing roadway, which eliminates the left-turn phase for this approach at the main intersection. Traffic that would normally turn left at the main intersection would first cross the opposing through lanes at a signal-controlled intersection about 300–400 feet (91–122 meters) upstream of the main intersection. The left-turning vehicles then travel on a new roadway parallel to the opposing lanes and execute the left turn with a signal simultaneously with the through traffic at the main intersection. Traffic signals at the main intersection and the locations of the left-turn crossovers are timed so that all vehicles (including left-turning vehicles) have at most one red phase to wait for.

Engineers have designed various types of DLTs, including one with fully displaced left-turn lanes on all four approaches to the intersection, and another with displaced left-turn lanes on either the main road or crossroad of the intersection.

Traffic Operations

The major benefit of DLTs involves increased throughput (comparable to capacity) by reducing the number of phases in a signal cycle and eliminating the left-turn phases. A soon-to-be-published Federal Highway



Shown here are the primary movements associated with the full DLT.

Source: FHWA.

Administration (FHWA) study, *Alternative Intersections/Interchanges: Informational Report* (in preparation), used a traffic simulation model to compare throughput results for the following four DLT cases to those of conventional intersections:

Case 1. Three lanes on the major road intersecting three lanes on the crossroad.

Case 2. Three lanes intersecting two lanes.

Case 3. Two lanes intersecting two lanes.

Case 4. A T-intersection with three lanes intersecting two lanes.

For a full DLT, three of the four approach cases (#1, 2, and 3) yielded 30 percent increases in throughput when the flows are fully balanced (that is, when approximately equal numbers of cars are traveling in each opposing direction). Case 4 increased throughput by 16 percent. Case 4 reveals a smaller increase in throughput because the reduction of phases for a T-intersection is only from 3 to 2. The reduction in phases of cases 1 to 3 (four-leg intersections) is from 4 to 2 for a full DLT and from 4 to 3 for a partial DLT.

When mainline opposing flows are unbalanced with a 30/70 directional split (for example 30 percent traveling north, while 70 percent are traveling south), the increase in throughput from comparable conventional intersections is as follows: case 1, 25 percent; case 2, 25 percent; case 3, 25 percent; and case 4, 12 percent.

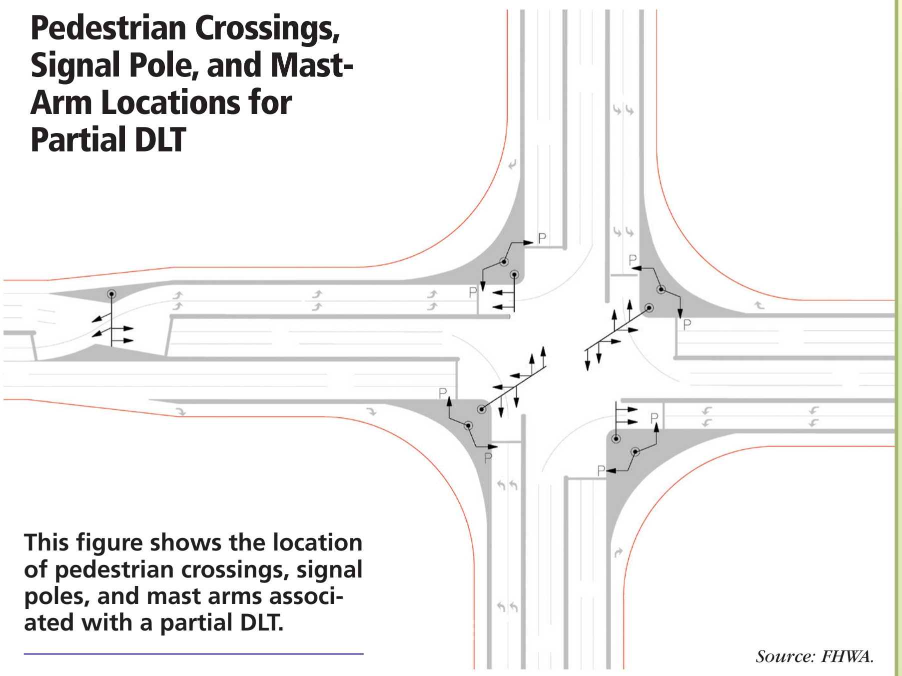
For a half or partial DLT, the increase in throughput of case 1 ranges from 14 to 20 percent from unbalanced to balanced flows. For case 2, the increase in throughput ranges from 10 to 20 percent from unbalanced to balanced flows. Cases 3 and 4 were not conducted for partial DLT.

Advantages and Disadvantages

Conversion to a DLT has some advantages over expanding capacity at a conventional intersection or changing to a grade-separated crossing. According to the FHWA study referred to above, *Alternative Intersections/Interchanges: Informational Report*, DLTs are much less expensive to construct compared to conventional grade-separated interchanges, and crews can build them in less time. At high-volume intersections, DLTs have the potential to reduce travel times considerably. Simultaneous movement of the left-turn and through traffic promotes improved progression of traffic platoons (moving of vehicles in groups where the vehicles are closely interspaced) on the arterial and increases vehicular throughput.

Considering potential safety benefits, a partial DLT has 30 conflict locations and a full DLT has 28, compared to a conventional intersection's 32 conflict locations. For both partial and full DLTs, the conflict points are more dispersed than at conventional intersections. In a conventional intersection, the traffic conflict points are concentrated

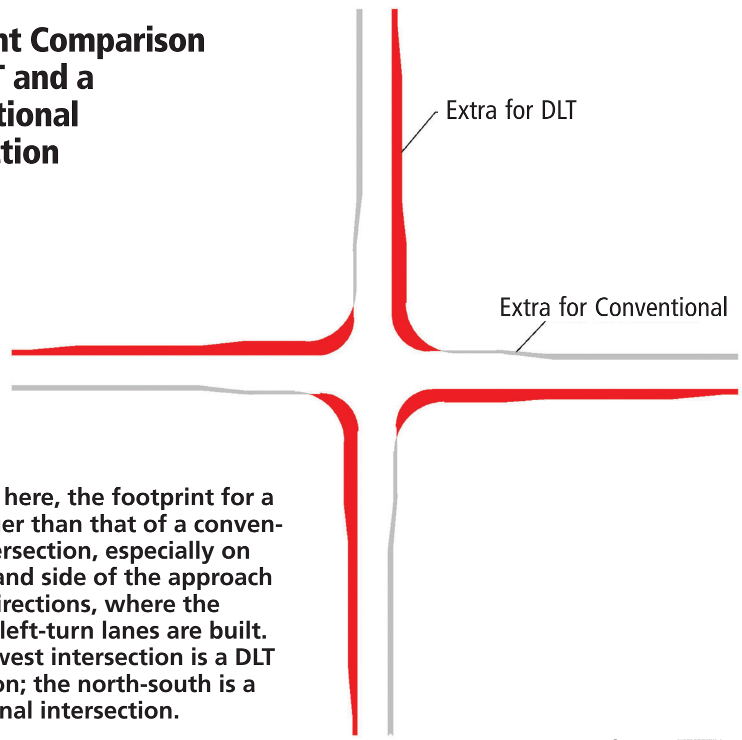
Pedestrian Crossings, Signal Pole, and Mast-Arm Locations for Partial DLT



This figure shows the location of pedestrian crossings, signal poles, and mast arms associated with a partial DLT.

Source: FHWA.

Footprint Comparison Of a DLT and a Conventional Intersection



As shown here, the footprint for a DLT is larger than that of a conventional intersection, especially on the left-hand side of the approach from all directions, where the crossover left-turn lanes are built. The east-west intersection is a DLT intersection; the north-south is a conventional intersection.

Source: FHWA.

Annual Average Collision Rates for Baton Rouge DLT

Year	Number of Reported Collisions By Severity		All Reported Crash Rate (per million entering vehicles on major road)	Fatal + Injury Crash Rate (per million entering vehicles on major road)
	Total	Fatal + Injury		
Annual Average "Before" (2002–2005)	147	37	5.09*	1.26*
Annual Average "After" (June 2006–May 2008)	111	30	3.87**	0.98**
Difference "After"–"Before" (Percentage Difference)	-36 (-24.4%)	-7 (-18.9%)	-1.22 (-23.9%)	-0.28 (-22.2%)

** AADTs for years 2003 and 2004 were interpolated.*
*** AADT for year 2006 was interpolated.*
Source: DOTD.

in the middle of the intersection. However, in a DLT intersection, the conflict points are distributed at multiple intersections (that is, the central intersection and the crossover points). The only crash data comparison available is from a Baton Rouge, LA, site, which has been in operation since 2006. A raw, before-after data comparison shows a reduction in total annual crash frequencies by 24 percent. Annual fatal plus injury frequencies went down by 19 percent. Total crash rates per million entering vehicles were reduced by 24 percent for total crashes, and fatal plus injury rates went down by 22 percent.

On the downside, DLTs have larger footprints compared to conventional intersections. This might be a significant factor in urban areas where right-of-way is limited and costly. Access to land parcels in the quadrants of a DLT can be restricted, and agencies might need to eliminate U-turns at DLTs. In addition, pedestrians must walk across ramps to cross certain legs, and the intersection design can be challenging to those with visual impairments because the paths and some traffic movements are atypical.

An FHWA study, *Evaluation of Sign and Marking Alternatives for Displaced Left-Turn Lane Intersections* (FHWA-HRT-08-071), using a driving simulator is finding economical and effective treatments that agencies can use at DLTs to help motorists recognize the left-turn crossovers upstream of major intersections. For instance, post-mounted signs on both sides of the road appear to work as well as mast-arm signs in guiding drivers to the correct paths.

The Baton Rouge Case

In recent years, traffic had become a serious problem for Baton Rouge, LA, given a backlog of State and Federal transportation projects awaiting funding. Fortunately, local engineers had been working on an innovative concept that would dramatically improve traffic flow at one of the city's busiest intersections.

In 2002, an engineering firm had approached the Louisiana Department of Transportation and Development (DOTD) with a recommendation to consider a DLT for highly congested signalized intersections in the State. The firm explained that conventional improvements, such as overpasses, are costly and interrupt businesses, and a DLT would be a viable alternative for solving urban congestion.

DOTD identified the intersection of Airline Highway and Sherwood Forest Boulevard/Siegen Lane as having the most potential for a DLT solution. Baton Rouge jumped quickly from an affirmative decision to construction.

The St. Louis Case

The Missouri Department of Transportation's (MoDOT) St. Louis Area District was seeking to provide more mainline green time at the intersection of MO 30 and Summit Road, because of growing traffic volumes. MoDOT estimated a 25 percent traffic increase by 2030. The mainline is a four-lane divided route, carrying more than 50,000 vehicles per day.

Simulation analysis estimated a typical traditional intersection design (including dual left-turn lanes on each approach) would have resulted in a delay in the peak hour of 110.1 seconds per vehicle, a level of service (LOS) of F (on a scale of A to F, where A corresponds to best service and F means worst), based on simulation analysis. The DLT, on the other hand, is expected to result in an average delay of 29.5 seconds per vehicle, with a LOS of C. Further, the traditional solution would have provided 54 of 115 seconds, or 47 percent, mainline green time, but the DLT completed in 2007 provides 74 of 115 seconds, or 64 percent, mainline green time. Another reason MoDOT ruled out a traditional interchange was that the site is too close to another interchange to allow for adequate weaving distances. (Weaving distance is the length of the roadway section where the vehicles from the expressway section change lanes to take the off-ramp, and vehicles entering the expressway section

This screen grab from FHWA's driving simulator shows a left-turn crossover movement on a four-lane highway, with two left-turn lanes branching off the northbound lanes and crossing the two southbound lanes before turning left (westward). Signs posted downstream of the left-turn lanes give motorists advance warning of the crossover displaced left-turn lanes. *Source: FHWA.*

Applications

In addition to the Baton Rouge and St. Louis sites, several other DLTs now are operating in the United States:

- Crews built a DLT prototype at a T-intersection at the entrance of the Dowling College National Aviation Technology Center in Long Island, NY, in 1996.
- The meeting of Route 210 (Indian Head Highway) and Route 228 (Berry Road) in Accokeek, MD, is a T-intersection that operates under a full signal. Built in 2000, the left-turn movement is on the side-street approach only, rather than on the major road approach.
- A DLT at 3500 South and Bangerter Highway in Salt Lake City, UT, opened in September 2007.

At the three-legged half DLT in Shirley, NY, shown in this aerial photograph, the DLT movement is on the side-street approach to the intersection, rather than on the major road approach.

from the on-ramp change lanes to merge with the expressway traffic.)

The DLT approach is not perfect, of course. "We get maybe four to six snowstorms every year with accumulation that needs to be plowed," says Jeanne Olubogun, P.E., traffic operations engineer with MoDOT's St. Louis District. "Our operations staff dislikes the islands created by the DLT because they complicate plowing, but they do understand the benefits." Notwithstanding these issues, the State decided that a DLT was the best option and proceeded to install it.

Overall construction of the DLT lasted about 8 months and cost $4.5 million, compared with $3 million for a traditional intersection. Construction was not without difficulty: The intersection is in a large rock cut, and much rock had to be blasted to build the new road connection and the DLT. "We had very few problems in traffic management during the transition from existing condition to the DLT," notes Olubogun. The increased cost for the project included the increased quantity of pavement for a DLT versus a standard intersection, additional islands constructed to separate conflicting movements, and the additional rock cuts to facilitate the larger footprint of the DLT intersection.

Promising Outlook For Navigation

Some transportation professionals feared DLTs would require an educational process for drivers, and experience shows that some acclimation may be needed. Large signs guide drivers to the displaced left-turn lane, which is itself intuitive and easy to follow, according to the latest summary report, *Evaluation of Sign and Marking Alternatives for Displaced Left-Turn Lane Intersections,* (FHWA-HRT-08-071). An educational process may be helpful to improve adaptation to this new design.

"Studying the map is more confusing than driving the intersection," says Michael G. Bruce, an engineer involved in the Baton Rouge project. "This is one of the reasons that safety has improved."

In fact, DOTD officials were concerned early on that the DLT concept would confuse Baton Rouge drivers during power outages and result in dangerous conditions. "The power went out for about 3 hours about a month after the CFI [DLT] opened," Bruce says. "The intersection happens to be near a State traffic camera, so we have 3 hours of video of drivers operating very safely. There was no confusion and no dangerous situation. The drivers knew exactly how to handle the intersection."

The DLT solution is also a much less expensive approach than overpasses. The Baton Rouge DLT is expected to cost about $5 million, compared to an overpass that would have cost about $30 million to build. "When you do need to acquire land, the DLT costs much less than a conventional overpass," Bruce says. A conventional widening

In this Baton Rouge, LA, intersection, the left-turn lane upstream of the main intersection crosses the median and the opposing side of through traffic to the displaced left-turn lane.

Steven Scott, MoDOT

This photograph shows a head-on view of traffic entering the DLT intersection on Route 30 in St. Louis, MO.

Ryan Pierce, MoDOT

This aerial shot shows the St. Louis intersection of Gravois Bluffs Boulevard and Summit Drive, with the DLT crossover upstream of the main intersection.

could provide comparable capacity improvement. However, the additional lanes in both directions of travel would have to be extended for a certain distance beyond the intersection to provide continuity. When more right-of-way is necessary, additional costs are difficult to estimate in comparison to the DLT unless the estimate is site-specific.

Getting Traffic Moving

The Baton Rouge and St. Louis cases are among several current success stories, with more likely to come. A two-legged DLT that opened in 2007 on the Bangerter Highway in Utah, similar to the Baton Rouge intersection, is proving successful, according to the Utah Department of Transportation (UDOT). Also, according to Lisa Wilson, P.E., UDOT Region 2 traffic operations engineer, "Several other cities and the traveling public are wondering when CFIs will be built at their intersections along the Bangerter Highway."

In addition, crews are building a DLT in Mississippi, and designers are drawing up two in Ohio.

Applicability

Replacing a conventional intersection with a full DLT intersection can produce a 50 to 85 percent reduction in average intersection delays and a 10 to 25 percent increase in intersection throughput, according to traffic simulation results. Replacing a conventional intersection with a half DLT intersection can produce a 30 to 40 percent reduction in average intersection delays and a 10 to 20 percent increase in intersection throughput. Some of the situations where a DLT intersection may be suitable are the following:

- If the volume/capacity ratio is greater than 0.8 on two opposing intersection approaches.
- If the product of left-turn and opposing through vehicles is greater than 150,000 on two opposing intersection approaches.
- If the left-turning volume is greater than 250 vehicles per lane and the opposing through volume is greater than 500 vehicles per lane during peak hours on two opposing intersection approaches.
- If an intersection is heavily congested with many failures of signal phases to handle peak traffic volumes.
- If left-turn queues at an intersection spill beyond the left-turn storage bays.

For more information, see FHWA's *Alternative Intersections/Interchanges: Informational Report* (in draft).

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by Matthew J. DeMarco, Scott A. Anderson, and Amit Armstrong

Retaining Walls Are Assets Too!

FHWA kicks off an inventory program for roadway support structures to assist management efforts at the National Park Service.

(Above) FLH engineers are helping NPS catalog and assess the structural health of the park system's retaining walls through a wall inventory program. Here, fresh snowfall at Mesa Verde National Park did not stop inventory team members from evaluating close to 50 walls, including this wood-lagged, tie-back soldier pile wall.

The U.S. Department of the Interior's National Park Service (NPS) is responsible for managing and maintaining nearly 5,000 miles (8,047 kilometers) of paved roads and parkways across more than 250 properties nationwide. Many of the scenic roads traversing the country's national parks were constructed by the Civilian Conservation Corps during the 1930s and are beginning to show their age. So too are the retaining walls and other support structures that secure, protect, uphold, carry, or otherwise convey these roads across challenging terrains. Unsung heroes among roadway infrastructure, these walls and other structural elements hold historic significance for NPS, and many have been preserved and rehabilitated over the years to meet modern traffic and safety requirements.

Like the roads themselves, numerous subsidiary roadway features, such as retaining walls, bridges, culverts, and traffic barriers, are critical assets that require careful maintenance and rehabilitation. Referred to as "equipment" in asset management parlance, these features are major contributors to the safety and accessibility of the NPS road system and represent substantial investments in roadway infrastructure. In addition to the pavement assets, NPS is responsible for appraising and managing the maintenance needs of all assets associated with the roads, including retaining walls and other equipment. Given the wide range of geographic settings and extensive public use of NPS roads, defining the backlog of roadway equipment needs in terms of location, quantity, condition, and failure consequences represents a major challenge for NPS.

Currently, NPS and the Federal Highway Administration's (FHWA) Office of Federal Lands Highway (FLH) collaborate to assess park roadways and bridges using two inventory programs: the Road Inventory Program (RIP) and Bridge Inspection Program (BIP). In 2005, the Park Facility Management Division of the NPS Washington Support Office commissioned FLH to develop an inventory program for retaining walls, similar in scope to the ongoing RIP and BIP inventories. The mission of the wall inventory program (WIP) is to define and quantify wall assets associated with park roadways in terms of their location, geometry, construction attributes, condition, failure consequence, cultural value, apparent design criteria, and cost of structure maintenance, repair, or replacement. The wall inventory will provide data to the RIP to update equipment assets associated with the parent roadway asset. NPS asset managers will periodically reassess retaining walls in the parks participating in the WIP to ensure that timely, accurate information is available to support NPS asset management initiatives.

The WIP data will feed into the Facility Management Software System, the existing data hub that NPS uses to document, manage, and plan efforts related to park assets. In this data management system, condition assessments for roadway and bridge structures are expressed as deferred maintenance costs, which are then divided by current year replacement costs to arrive at a facility condition index (FCI). According to the NPS report *Budget Justifications and Performance Information* for fiscal year (FY) 2006, "to ensure that its capital asset investments are made as efficiently as possible, the NPS is incorporating FCI analysis into the prioritization process by comparing the existing FCI of a facility against the proposed FCI after the construction investment." Coupling this condition prioritization with an asset priority index, which measures the facility's importance to a park's mission, NPS managers can make more informed decisions on capital investments, focusing maintenance and construction priorities on value rather than cost alone.

Developing the WIP has been a multiphase effort, with FLH division office and NPS personnel sharing responsibility for each task. The phases included researching existing

Prior to beginning field work, team personnel trained on the proper use of safety harnesses and ropes for accessing steep, highly exposed wall faces. Here, geologist Charlie Martinez, of the Central Federal Lands Highway Division, is shown at a training site west of Denver.

At Mount Rainier, a team surveys a mortared stone masonry wall. One person measures wall dimensions while the other records element conditions.

State inventory programs, developing a customized wall inventory and assessment system suited to NPS asset management requirements, and piloting the methodology at several national parks. FLH took the lead on performing field inventories, while NPS handled integrating the WIP data into its data management system. Since the program launched in 2005, the agencies have completed wall inventories capturing condition assessments and deferred maintenance costs for nearly 3,500 retaining walls within the WIP database.

Over time, "the WIP will benefit NPS in several ways," says WIP Project Manager Dave Keough, with the Park Facility Management Division, NPS Washington Office. Having developed the WIP, "we have credible documentation of the total value of roadway retaining walls, as well as the cost needed to repair and maintain them. This goes a long way when trying to justify budget requests. It also provides solid information for various park units to prepare sound project proposals. When future projects are in development, this information can save money and improve designs."

Program Conception

Based on their experience with the BIP, the WIP development team decided that the WIP should be more than just an inventory program, says John R. Thiel, P.E., bridge management team leader with FHWA's Eastern Federal Lands Highway Division. "The BIP is essentially a safety program, following the National Bridge Inspection Standards that were written into law after bridge collapses had caused loss of life. BIP assesses the condition of each structure and develops recommendations and cost estimates for corrective actions. A bridge management system then utilizes these data and other tools, such as priority indices, to systematically develop and prioritize bridge improvement projects. Based in part on the BIP and bridge management system models, the WIP utilizes a database that stores information provided by inspectors regarding wall conditions, needs, and indices that establish risk and priority for repair of each wall."

In 2005–2006, FLH investigated the feasibility of developing and conducting retaining wall inventories for NPS. Preliminary efforts provided early recommendations for inventory methods and practices supporting the needs of the NPS data management system. More specifically, initial efforts concentrated on the following six tasks: (1) a state-of-the-practice review; (2) identification of the range of wall types and components, and estimation of costs for wall rehabilitation, repair, and replacement; (3) determination of inventory size and breadth; (4) development of a plan to collect wall data that is consistent with existing FLH bridge and road inventory programs; (5) development of a methodology for assessing the condition of wall components; and (6) development of procedures to document cultural resource issues.

Although each of these tasks helped define the current inventory program, FLH officials cite their review of practices underway within Federal, State, and local agencies as the most influential factors in developing the WIP for NPS. FLH canvassed 23 State departments of transportation (DOTs), partner land management agencies, and several major municipalities for experiences with retaining wall inventories. Most of the surveyed agencies reported having bridge and/or roadway inventories tied to an asset management system, but few had moved beyond acknowledging the need to

This retaining wall at Glacier National Park illustrates just one of the finer points captured within the WIP inventory: The need for inspectors to determine whether a structure is a retaining wall with a historic culvert or a culvert headwall.

Retaining walls associated with bridges may or may not qualify for the WIP inventory. FLH inspectors determined that this dry-laid stone masonry wall in Acadia National Park supports the bridge approach and should be included in the WIP survey. The mortared stone masonry wall along the bridge abutment, however, would be assessed under the Bridge Inspection Program.

incorporate retaining walls into their asset programs. In fact, only seven DOTs and one municipality had any substantive experience with identifying and inventorying wall assets. In most of these cases, the inventories are limited to simple cataloging systems tied to existing bridge or roadway infrastructure surveys, include only new walls—that is ignore the backlog of existing structures—or focus only on one particular wall type, such as mechanically stabilized earth (MSE) structures.

Prior to WIP development, the Washington State Department of Transportation and Colorado Department of Transportation both had developed extensive wall inventory and assessment methodologies but had yet to implement their programs fully, primarily due to the associated high costs of performing field assessments on thousands of walls statewide. Of the transportation authorities canvassed, as of 2006, the Oregon Department of Transportation (ODOT) was the only one to actually implement a statewide asset management system. Under the planned auspices of an Office of Asset Management, ODOT's program integrates some 62 inventory components spanning structure assessments, financial elements, and asset planning.

In addition to State DOT efforts, the city of Cincinnati has a formal wall inventory system in place, largely modeled after its bridge inspection and inventory program. As of 2006, the city had inventoried approximately 1,800 retaining walls, representing nearly 60 miles (97 kilometers) of wall length and more than $170 million in current year replacement value.

The preliminary review of existing wall inventory efforts underway within the transportation community resulted in several key findings that guided development of the WIP for NPS:

Program cost. Streamlining data collection processes and procedures can minimize costs. The tendency to develop broad, all-encompassing engineering assessments often results in impressive data collection schemes on paper that only later are determined to be prohibitively expensive to implement on the ground.

System integration. Stand-alone inventory systems can greatly simplify processes during system development, but a common database architecture and software platform is critical to future integration with other asset management efforts.

Qualified inspection. Accurate asset data underpins an effective asset management program. The collection of high-quality data on wall conditions is directly related to the careful definition of wall attributes and elements, plus training qualified field inspectors.

WIP Development

Following conceptual development of the WIP in 2006, FLH and NPS team members defined approximately 65 wall attributes that should be logged, measured, calculated, or assessed during field inventories. They also developed procedures, forms, and associated guides and cost information for collecting data in the field, and then created a Microsoft Access®-based, searchable WIP database. The team also conducted several pilot studies in the summer and fall of 2006, for example, at Sequoia National Park and Crater Lake National Park.

"The biggest surprise for me was just how difficult it is to consistently define, measure, and categorize all the different kinds of walls we encountered," Keough says. "The condition assessment, which would seem to be the more difficult task, was often easier than just figuring out what kind of wall the inspector was looking at."

In some circumstances, for example, inventory teams can encounter difficulties in classifying a particular wall's function or in determining whether a structure qualifies for inclusion in the inventory at all. Is the wall on the inside of a switchback, a fill wall, or a cut wall? Should it be considered a wall with a culvert, or a culvert headwall? Is it an integral part of the bridge wingwall and, therefore, covered under the BIP, or does it primarily support the bridge approach? Is it a parapet extending above a wall, or is once-retained-earth missing from the top of the wall? During development of the WIP, the inventory team often faced the challenge of describing these types of walls. Further still, the wall inventories represented only an initial screening of wall asset needs for a given park. More detailed assessments will be necessary before the parks can begin programming wall repairs or complete structure replacements.

The inventory team used five general data categories to describe measure, evaluate, and rate wall attributes and to define and quantify WIP assets.

Wall location. The team identified the location of walls by park name, route number and name, side of roadway, start and end mile points for the wall, and latitude and longitude of start of the wall.

Wall description. Walls are described by function, type, year built, architectural facings, and surface treatments. The team recorded measurements for wall length, maximum height, face area, face angle, and vertical and horizontal offsets from the roadway. Inspectors photographed each wall, noting location relative to the roadway, major wall features, and overall element conditions.

Wall condition assessment. Inspectors described conditions of the primary and secondary wall elements relative to the extent, severity, and urgency of observable distresses, and then rated them numerically, giving due consideration to data reliability. They also evaluated and rated overall performance of the wall system (global performance of the entire wall system), with all ratings weighted and combined to arrive at a final, overall wall condition rating.

Wall action assessment. To determine a recommended action, the team considered the following: (1) the final numerical condition rating of the wall element, (2) any identified requirements for further site investigations (measure of data reliability), (3) the apparent design criteria employed (such as American Association of State Highway and Transportation Officials criteria), (4) any cultural concerns (such as a historic or a context sensitive wall), and (5) the consequences of wall failure. Potential actions included no action/monitor the wall, conduct maintenance work, repair wall elements, replace wall elements, and replace the entire wall.

Work order development. Where work orders are needed, the team provided brief, yet descriptive work orders to outline maintenance, repair, or replacement actions. They generated unit costs for major work items from the WIP Cost Guide (a compilation of cost data for repair and replacement) and/or available cost data from the park to arrive at preliminary estimates of cumulative deferred maintenance.

Of the 23 primary and secondary wall elements defined in the WIP, inspectors in the field needed to describe only those that were applicable to the particular site (generally 5–15). The resulting concise, written narratives characterized the severity, extent, and urgency of element distresses. Inspectors described wall conditions within four general distress categories: corrosion/weathering, cracking/breaking, distortion/deflection, and lost bearing/missing elements. Then they determined the condition ratings by applying a rating scale that ranges from 1 to 10, with 10 being best condition and 1 being worst.

The requirement for sound engineering judgment in the WIP is most apparent in the manner in which inspectors recommended wall actions. Whereas similar condition-based inventory systems might directly correlate a numerical rating to a specific action, the WIP assessment methodology provides a numerical condition rating for applicable wall elements, which asset managers then can consider objectively relative to other influencing factors (such as the consequences of wall failure) to arrive at a recommended action.

The WIP accounts for both primary and secondary wall types. Here, at Colorado National Monument, an inspector assesses a mortared stone masonry culvert headwall topped by a secondary dry-laid stone wall.

Retaining Wall Acceptance Criteria

(1) The inventory includes retaining walls, together with qualifying culvert headwalls, located on all classes of paved roadways and parking areas, as either surveyed under the Road Inventory Program (RIP) or identified by park facilities, maintenance, or resource staff.
(2) The retaining wall must reside within the existing roadway or parking area prism, generally defined within the known or assumed construction limits, and must support or protect the roadway or parking area.
(3) The maximum wall height, measuring only that portion of the wall structure intended to actively retain soil and/or rock, must be greater than or equal to 4 feet (1.2 meters). For culverts, maximum headwall/wingwall heights must be greater than or equal to 6 feet (1.8 meters).
(4) When known or verifiable, wall embedment may be considered in determining maximum retaining wall height for wall acceptance; however, embedment is not considered for wall face area dimensioning or condition rating.
(5) Covered or buried retaining structures, known to meet the aforementioned wall height requirements, are included in the inventory when locations are known or verifiable.
(6) Walls are further defined by an internal wall face angle greater than or equal to 45° (≥1H:1V face slope ratio).
(7) When wall acceptance based on the above criteria is marginally difficult to discern, include the wall in the inventory, particularly where the intent is to support or protect the roadway or parking area and where failure would result in significant impacts, requiring replacement with a similar structure.

Source: FHWA, National Park Service Retaining Wall Inventory and Assessment Program—Procedures Manual.

Other influencing factors include the cultural and historical significance of the structure—an important aspect for the park program—and the reliability of the condition assessment data. The result is the selection of an appropriate action founded on a well-documented element condition and wall performance assessment, suitable for development of repair/replace work orders and associated cost estimates. The current wall assessment methodology meets the comprehensive WIP goals of identifying walls in need of maintenance, repair, or replacement; facilitating statistical assessments of wall elements throughout the entire WIP database; and providing a baseline for future wall assessments.

Initial Park Inventories

Field data collection, storage within the WIP database, and transfer to the NPS data management system began in April 2007. By February 2008, the inventory team had completed assessments on more than 3,500 retaining walls in 33 national parks, monuments, and recreation areas. This initial inventory, thought to encompass the majority of retaining wall structures within the NPS road system, serves as the basis for updated program developments included in the soon-to-be-released FHWA publication *National Park Service Retaining Wall Inventory Program—Procedures Manual*.

Aside from providing data on wall-specific deferred maintenance to the NPS data management system, the WIP database also can be queried to characterize and evaluate aspects of the entire NPS retaining wall asset—one that until now had been undefined. General findings to date include the following:

Wall functions. Of the six wall functions inventoried in the WIP—fill walls, cut walls, headwalls, switchback walls, bridge walls, and slope protection—approximately half represent outboard fill walls (downslope side of the roadway). If including culvert headwalls as a type of fill wall, then nearly 90 percent (based on WIP data) of all walls are designed and built to retain fill. Culvert headwalls supporting roadway assets comprise an overwhelmingly large percentage of the wall database. This leads to the question, as agency owners move to inventory and manage their culvert assets, where should culvert headwalls be included? The NPS inventory results show that culvert headwalls typically are small gravity structures in generally good condition. Including these structures in the inventory tends to bias and mask database

Some walls are well off the roadway but still critical to road stability. This inspector is reviewing an ashlar (square) architecturally faced stone masonry structure at Colorado National Monument. The wall supports outboard fill along the main park roadway.

Team members at Mount Rainier National Parks have their hands full inventorying this multitier, large-block, dry-laid stone masonry wall.

performance trends for what could be considered the more traditional retaining walls, suggesting they are more appropriately assessed under culvert inventories. In comparison, cut walls comprise approximately 10 percent of the inventory, and a very small percentage of the walls are classified as slope protection, switchback walls, or bridge walls.

Wall types. Although the inventory team identified 17 distinct wall types, few dominate the database. Nearly all culvert headwalls, and 40 percent of all walls, are mortared stone masonry gravity structures. Dry-laid stone masonry walls comprise another 35 percent of the inventory. Most of these stone masonry structures were built in the first half of the 20th century. Of the 15 different wall types making up the remaining 25 percent, concrete gravity and concrete cantilever walls are relatively common. The inventory has only a few segmental block MSE walls and metal crib walls, and only one MSE wall with a geosynthetic wrapped face. "The distribution of wall types is probably indicative of the setting where and when the walls were constructed, and the relatively narrow timeframe during which most were built," says Keough. "Different owners and DOTs might find a completely different distribution."

Wall element ratings. As noted earlier, the number of wall elements rated varies with the different types of walls, generally ranging from 5–15 elements depending on the number of wall components and setting features. Nevertheless, when the team calculated the overall wall ratings, the maximum, mean, and minimum ratings remained generally consistent across the various wall types, indicating the WIP successfully quantifies wall condition within a reasonable band and with enough variation in scores that prioritization is possible.

Recommended actions. Thus far in the program, and for most wall types with significant populations (the number of inventoried walls in each type category), approximately one-third of the walls require some type of corrective action, mostly either maintenance or minor repairs to localized elements. These actions are relatively low cost and could be incorporated into a routine maintenance program. Less than 3 percent of the inventoried walls have recommendations to replace all or parts of the wall, suggesting that the asset as a whole is still in acceptable condition, and that a recurring maintenance program would go a long way toward keeping it that way.

Work order cost estimates. Any time an inspector recommends a maintenance, repair, or replacement action, he or she needs to prepare and submit a work order to the NPS data management system defining the work items and associated costs. Based on the NPS inventory, maintenance recommendations are most common and least expensive, averaging about $4,000 per wall. Recommendations to repair or replace localized wall elements are less common and have average costs ranging from $25,000 to $35,000. Total costs for wall replacement average about $150,000. The team estimates total deferred maintenance costs to date are approximately $18.5 million, with an estimated inventory replacement

Element Condition Rating

9–10 Excellent	No to very low extent of very low distress. Any defects are minor and are within the normal range for *newly constructed* or *fabricated* elements. Defects may include those typically caused from fabrication or construction. Ratings of 9 to 10 are only given to conditions typically seen shortly after wall construction or substantial wall repairs.
7–8 Good	Low to moderate extent of low-severity distress. Distress present does not significantly compromise the element function, nor is there significant severe distress to major structural components of an element. Ratings of 7 to 8 indicate highly functioning wall elements that are only beginning to show the first signs of distress or weathering.
5–6 Fair	High extent of low-severity distress and/or low to medium extent of medium- to high-severity distress. Distress present does not compromise element function, but lack of treatment may lead to impaired function and/or elevated risk of element failure in the near term. Ratings of 5 to 6 indicate functioning wall elements with specific distresses that need to be mitigated in the near term to avoid significant repairs or element replacement in the longer term.
3–4 Poor	Medium to high extent of medium- to high-severity distress. Distress present threatens element function, and strength is obviously compromised and/or structural analysis is warranted. The element condition does not pose an immediate threat to wall stability and closure is not necessary. Ratings of 3 to 4 indicate marginally functioning, severely distressed wall elements in jeopardy of failing without element repair or replacement in the near term.
1–2 Critical	Medium to high extent of high-severity distress. Element is no longer serving intended function. Element performance is threatening overall stability of the wall at the time of inspection. Ratings of 1 to 2 indicate a wall that is no longer functioning as intended, and is in danger of failing catastrophically at any time.

Source: FHWA, National Park Service Retaining Wall Inventory and Assessment Program—Procedures Manual.

Many of the culvert headwalls inventoried nationwide were deemed historic resources, such as this mortared stone masonry headwall in Glacier National Park.

cost of nearly $407 million. This total equates to a program-wide facility condition index of 0.045, a relatively low index value, which further corroborates the belief that the total wall asset—all of NPS's retaining walls and other equipment as a whole—is in reasonably good health.

Future Efforts

The results of the program to date indicate that conducting a comprehensive wall inventory across all remaining NPS properties is not necessary to adequately characterize the condition of the overall asset and facilitate planning for annual catch-up on deferred maintenance activities.

Although specifically designed to serve the NPS data management system, the WIP methodology could prove useful for application among a broader national audience, as Federal, State, and local agencies look to tackle issues regarding their retaining wall assets. "This asset management system for retaining walls is both versatile and simple," says Daniel Alzamora, a geotechnical engineer with the FHWA Resource Center, "and it could be a cost-effective model for others to adopt."

Although this stone masonry headwall at Acadia National Park is supporting the roadway, locating and accessing small wall features like this one can be difficult in highly vegetated areas. Western parks tend to be more arid and less vegetated; however, parks in the lusher Eastern United States generally require fall or winter surveys, once the leaves have fallen and undergrowth has withered.

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Amit Armstrong manages the technology deployment program at FHWA's Western Federal Lands Highway Division in Vancouver, WA. He has been with FHWA for 7 years, coordinating deployment of new, innovative, emerging, and underutilized technologies in design and construction of roads on Federal lands projects. He has more than 20 years of experience in numerical simulation and visualization of natural systems and is a licensed professional engineer. He received his doctorate in civil engineering from Texas Tech University.

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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.

Technical News

University of Minnesota Tests Self-Consolidating Concrete in Prestressed Girders

A team of researchers at the University of Minnesota recently completed a multiyear study of prestressed bridge girders made from self-consolidating concrete (SCC), a highly workable material that spreads into place without mechanical vibration.

University of Minnesota researchers found that prestressed concrete girders cast with self-consolidating concrete and no vibration (shown here) require fewer surface repairs than those cast with conventional concrete and internal vibration. *Photo: Bulent Erkmen.*

The university researchers collaborated with the Minnesota Department of Transportation (Mn/DOT), which sponsored the study, and local fabricators to develop SCC mixes based on locally available materials, and then used those mixes to fabricate prestressed bridge girders and cylinders. The mixes used an assortment of cementitious materials, aggregates, and admixtures. The researchers evaluated the properties of the SCC mixes using a variety of tests they developed to determine how well the mixes flowed, how easily the coarse aggregates could pass through reinforcing obstacles, and how resistant the mixes were to segregation.

The SCC girders performed comparably to conventional concrete girders, with measured prestress losses generally agreeing with predictions. Further, the researchers determined that models of creep and shrinkage based on data from the test cylinders can give reasonable predictions of prestress losses for both conventional and SCC girders.

To download or order a copy of the study report, Self-Compacting Concrete (SCC) for Prestressed Bridge Girders *(Mn/DOT 2008-51), visit www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1682.*

University of Minnesota, Center for Transportation Studies

Public Information and Information Exchange

Virtual Workshops Help DelDOT Cut Costs

The Delaware Department of Transportation (DelDOT) is adding a new format for its public workshops. For certain types of projects, instead of hosting in-person workshops, the department now will conduct "virtual" meetings, cutting costs related to staff and contractor compensation and overtime, room rentals, and fuel. The virtual workshop format represents a new tactic in the department's toolkit for communicating with the public at various stages of a project's life cycle.

A virtual workshop consists of a Web page that includes information about a proposed transportation project, such as design plans, detour routes, and current photographs. The virtual workshop enables members of the public to respond to project-specific questionnaires and surveys online. Using the Web site's multimedia component, DelDOT officials can share project information through audio and video presentations as well.

DelDOT held its first virtual workshop in January 2009 for the Sandy Bend Road Bridge project. According to DelDOT representatives, this project was a good fit for a virtual workshop because the proposed bridge improvements are minor and affect a relatively small number of residents and businesses. DelDOT will continue to hold live public meetings for high-profile projects, which tend to attract more people and warrant the associated costs.

For more information, visit www.deldot.gov.

DelDOT

IABSE Offers Free, Online Publications Archive

The International Association for Bridge and Structural Engineering (IABSE) recently made its archive of publications from 1929–1999 available to the public online. The archive contains more than 80,000 pages of historical documents on structural engineering worldwide, all of which are accessible for free to students, researchers, transportation professionals, and the public.

The IABSE archive covers a broad range of topics dealing with structures (such as bridges, highrise and industrial buildings, and sports stadiums), materials (such as concrete, steel, composites, timber, glass, and plastics), and phases of the construction process (such as planning design, construction, operation, monitoring, maintenance, rehabilitation, and demolition). A major component of the archive consists of reports collected from IABSE conferences. Also included are other IABSE series and periodicals. Some publications are available in French and German.

Advanced search functionality enables site visitors to perform full-text searches for words anywhere in the documents. Or visitors can browse the archive by title, author, or year to find information on research, projects, and other IABSE activities.

For more information, visit www.iabse.org/publications/archive.

IABSE

FHWA to Develop Long-Term Plan For Pedestrian Safety

The Federal Highway Administration's (FHWA) Offices of Safety and Safety Research recently began a project that will create a comprehensive strategic plan for the agency's pedestrian safety program. The strategic plan will be data driven, using crash and injury data to identify and prioritize research, development, and deployment gaps needed to reduce pedestrian fatalities. The plan will provide the framework for the big picture in pedestrian safety over the next 15 years.

As part of the project, FHWA staff will contact pedestrian and bicycling stakeholders to assess the use of previously developed products and materials to determine if they were effective in helping improve pedestrian safety and accessibility. FHWA is interested in seeing how stakeholders have used the products, how products could be improved, and what types of products might be useful in the future. Some of the products the agency intends to evaluate include the *Pedestrian Forum* newsletter, the Safer Journey (pedestrian) and Bicycle Safer Journey CD-ROMs, the Pedestrian and Bicycle Crash Analysis Tool, *University Course on Bicycle and Pedestrian Transportation* (FHWA-HRT-05-085), PedSafe and BikeSafe tools, the report *How to Develop a Pedestrian Safety Action Plan* (FHWA-SA-05-12), materials for FHWA's Pedestrian Safety Campaign, and assorted materials for Hispanic pedestrians and bicyclists.

The final plan is scheduled for completion in September 2010.

Highways for LIFE Wins Gold Award for Marketing

FHWA's Highways for LIFE program recently won a MarCom Gold Award from the Association of Marketing and Communication Professionals for the program's DVD toolkit on prefabricated bridge elements and systems. The award recognizes outstanding achievement in marketing and communications worldwide.

The winning DVD, "Prefabricated Bridge Elements & Systems Toolkit" includes two videos, four article reprints, a report on bridge technology decisionmaking, a manual on self-propelled modular transporters, and Web links. The Highways for LIFE team created the toolkit in DVD format so it can update and easily distribute new materials without the hassle of reprinting each individual piece.

The association received more than 5,000 entries from the United States and abroad for the 2008 competition. Judges selected winners in seven forms of media and communications, including marketing, publications, marketing/promotion, public service/pro bono, creativity, and electronic/interactive.

For a copy of the DVD, contact Lizzie Morris at 202-366-0131 or elizabeth.pollock@dot.gov. For more information, contact Kathleen Bergeron at 202-366-5508 or kathleen.bergeron@dot.gov.

FHWA's Highways for LIFE program won a MarCom Gold Award, like the one shown here, for its DVD toolkit on prefabricated bridge elements and systems. *Photo: The Association of Marketing and Communication Professionals.*

TRISworld Now Available to TRB Sponsors

The Transportation Research Board (TRB) recently launched the "TRISworld" Web site, which provides access to the world's largest and most comprehensive bibliographic resource on transportation research information. TRISworld is accessible by employees of TRB sponsor organizations and enables sponsors to search both the Transportation Research Information Services (TRIS) database and the English language records of the International Transport Research Documentation database.

TRISworld provides access to more than 727,000 records of published international transportation research, and more than 47,000 records now have links to full text documents. The new Web site offers both simple and advanced search screens. Site visitors can browse recent publications by mode, and then print, download, or e-mail records.

TRB sponsors can log into TRISworld at http://trisworld.trb.org. For a list of TRB sponsors, go to www.TRB.org. For more information, contact Barbara Post at bpost@nas.edu.

TRB

Road Safety Audit Software Available

Road safety audit (RSA) software, developed by FHWA's Office of Safety, now is available from FHWA's "RSA" Web site at http://safety.fhwa.dot.gov/rsa/software. The free software can assist auditors in drafting RSA reports and recording safety issues by enabling them to access prompt lists by topic and location. Prompt lists are one of the tools auditors use while conducting RSAs to identify potential safety issues.

A prompt list works differently from a checklist. The drawback of a checklist is the temptation for the auditors to simply tick the box rather than use the lists as an aid for applying their own knowledge and experience to the assessment. The software addresses these challenges by providing an opportunity for auditors to consider each safety issue through discussion and assessment. The software also supports the practical implementation of the *FHWA Road Safety Audit Guidelines* (FHWA-SA-06-06).

The goal of the software is to enable RSA team members to think about broader issues during the safety performance examination and to justify their findings and recommendations.

To download the software, visit http://safety.fhwa.dot.gov/rsa/software.

NATIONAL HIGHWAY INSTITUTE

Training Update

by Alicia Sindlinger

NHI Training Adopts Blended-Learning Approach

Because of organizational and personal budget constraints, the world of adult learning is evolving to help accommodate training needs. Traditional instructor-led training offers the benefit of face-to-face interaction, but it often involves costly travel and time away from the office. Also, from the individual learner's perspective, this approach tends to disregard the specific needs of each learner and follows a pace set by the instructor. Training that follows a self-study approach reduces travel time and costs, and enables the learner to proceed at his or her own pace. Yet self-study has drawbacks too, such as a lack of active feedback and guidance, and the possibility of the participant losing interest.

The National Highway Institute (NHI) is exploring options to mitigate the shortfalls of both traditional instructor-led training and courses that are entirely self-study. Specifically, NHI is modifying some courses to follow a blended-learning approach that combines the best attributes from instructor-led and self-study methodologies. Blended learning entails offering training that consists of instructor-led portions as well as self-paced online study.

"A well-designed blended-learning event should provide enough flexibility and control for the participant to shape and craft the direction of his or her own learning," says Thomas Elliott, NHI training program manager. "In this way, each participant, including the instructor, gets exactly what he or she wants out of the learning event."

Blended Learning at NHI

One example of a blended-learning offering at NHI is the course Principles and Practices for Enhanced Maintenance Management Systems (FHWA-NHI-131107). The course is an introduction to the methods used in enhanced management to maintain and operate a highway network. The training combines three online sessions with an instructor, self-study lessons, and workshop activities.

The target audience includes individuals who are responsible for managing maintenance operations and budgets, selecting maintenance projects and treatments, and monitoring systems conditions. Throughout the course, activities and assignments require participants to use the enhanced management system. One activity is a workshop that provides participants the opportunity to simulate decisions that must be made when determining the assets to include in transportation investments. Participants learn the process of prioritizing various asset types.

A Fresh Perspective

Overall, feedback on blended-format courses has been positive, Elliot says. Katie Zimmerman, president of Applied Pavement Technology, Inc., who instructed a pilot course in the blended format, agrees. "This was a great experience. I loved the blended format because the online instructor-led portions enforce key points from the self-study material, and the activities really engaged the participants."

Because blended-learning approaches generally involve online course materials, one of the biggest challenges in adapting existing content from a classroom setting to a Web-based environment is recreating materials that can stand alone, without the direction of an instructor. According to Elliott, "a blended approach should take a fresh look at the course's learning outcomes and then design the materials in a format and manner most appropriate to allowing the participants to achieve those outcomes."

NHI is working on converting several traditional courses into blended-learning formats. For example, two courses in the safety programs area, Low-Cost Safety Improvements, Blended Approach (FHWA-NHI-380083) and Interactive Highway Safety Design Model (FHWA-NHI-380071), should be available in the new format by late 2009.

For more information on blended learning at NHI, contact Thomas Elliott at 703-235-0319 or thomas.elliott@dot.gov. A full description of NHI courses can be found at www.nhi.fhwa.dot.gov.

Alicia Sindlinger is a contributing editor for PUBLIC ROADS.

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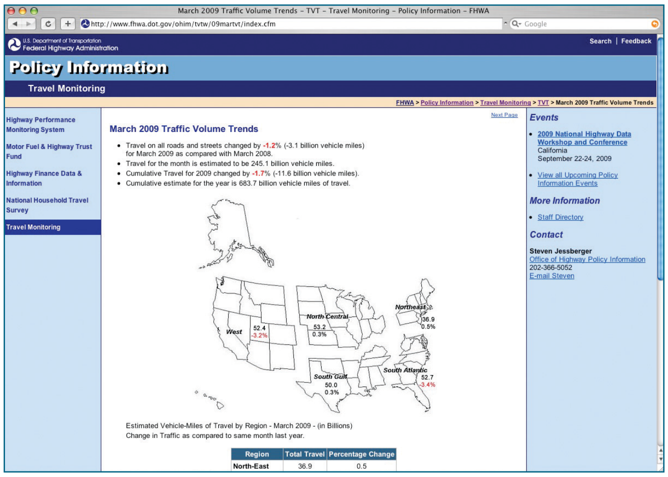
NHI aims to make training available to more transportation professionals by offering courses in flexible, blended-learning formats that include self-study portions coupled with instructor-led and group activities.

by Alicia Sindlinger

Demystifying Traffic Volume Trends

Data on traffic volume trends on U.S. highways are essential to many transportation functions, including infrastructure and maintenance planning. Traffic trends also are vital to other stakeholders, such as the tire industry, which uses the monthly estimates to determine production schedules.

Each month, the Federal Highway Administration's (FHWA) Office of Highway Policy Information compiles information on trends in traffic volume across the country. "These monthly estimates have grown progressively more relevant to discussions ranging from economic vitality to the future of the Highway Trust Fund," says Doug Hecox, deputy associate administrator for FHWA's Office of Public Affairs. "These data, which have been compiled by FHWA for years, are now among the most highly anticipated data produced by the Federal Government."



FHWA's "Traffic Volume Trends" Web site (shown here) provides information on monthly changes in vehicle travel in the United States.

FHWA publishes the *Traffic Volume Trends* reports, which estimate vehicle miles traveled (VMT) on U.S. public roads, within 6–8 weeks of the close of a given month. These data are available to the public at www.fhwa.dot.gov/ohim/tvtw/tvtpage.cfm.

The reports contain data demonstrating the changes in VMT by region and State, VMT changes on rural and urban arterial roads by region and State, and VMT changes on all estimated roads by region and State. Also included are rural and urban volume trends by quarter and graphs of travel trends by month and year. The Web site makes it possible to compare trends over 35 years with monthly VMT estimates dating back to 1970 and annualized data back to the 1940s.

States Gather and Report Data

States are responsible for reporting monthly traffic counts to FHWA through the Travel Monitoring Analysis System, an online portal through which States submit their data. State highway agencies collect the data through permanent, automatic traffic recorders, such as inductive loops, installed on public roads. Approximately 4,000–5,000 continuous traffic counting locations exist nationwide, each of which reports data in 5–10 minute intervals.

FHWA estimates VMT by State and several functional classes of roads. The estimates are based on two sources of data: the data reported by States and the Highway Performance Monitoring System, which pulls data from sensors mounted in roads. Monthly average daily traffic is computed using the States' traffic counts. FHWA analysts use the data to estimate the percent change in traffic for the current month compared with the same month in the previous year. Next, they average the change rates by functional class of road and estimate monthly VMT by combining the change rates for each month with the most recent annual VMT from the Highway Performance Monitoring System.

FHWA runs quality control checks on all data received. Analysts review data reported from the traffic recorders, looking for inconsistencies. Data with inconsistencies caused by any number of factors (such as malfunctioning recording devices, traffic incidents that block roads, and snow) are replaced with estimates from nearby traffic recorders. FHWA uses only data that pass the quality control checks in the *Traffic Volume Trends* reports. Another criterion: The data collected must represent a minimum of 30 States and 70 percent of the VMT in order for FHWA to publish a report.

Recent Trend: A Decline in Driving

January 2009 marked the 14th consecutive month of declining driving. From December 2007–January 2009, the decline topped 122 billion VMT compared to the same period a year earlier (December 2006–January 2008). In January 2009 alone, travel on all roads and streets was 3.1 percent less, or 7 billion fewer VMT, than January 2008. According to the reports, cumulative travel for 2008 fell 3.6 percent, or by 107.9 billion VMT, compared to 2007.

"We are watching this trend closely," says Hecox. "When it was first identified in late 2007, we believed it had to do with rising fuel prices. However, when fuel prices began to normalize after cresting in July 2008, traffic levels continued to fall—suggesting that the factors may be an array of economic variables. Joblessness may play a role in declining driving, but so too might overall consumer confidence. This change in driving behavior will surely be studied by academics and theoreticians in the years to come but, for now, no specific cause has yet been identified."

The relevance of these data has never been more apparent, Hecox says, especially due to the connection some are making between the trend and the Nation's economy.

For more information, visit www.fhwa.dot.gov/ohim/tvtw/tvtpage.cfm.

Alicia Sindlinger is a contributing editor for PUBLIC ROADS.

Communication Product Updates

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

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

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

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

Requests for items available from FHWA's Product Distribution Center should be addressed to:

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Szanca Solutions/FHWA PDC
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Claysburg, PA 16625
Telephone: 814–239–1160
Fax: 814–239–2156
E-mail: report.center@dot.gov

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

Evaluation of Sign and Marking Alternatives For Displaced Left-Turn Lane Intersections: Summary Report
Publication No. FHWA-HRT-08-071

In recent years, FHWA has researched certain novel intersection designs as a means to improve intersection safety while meeting the often conflicting demands to increase capacity, decrease travel time, and minimize the cost of new infrastructure. One of these designs, the displaced left-turn lane intersection (DLT), is in the early stages of deployment in the United States. This report describes FHWA research on signing and marking of DLT intersections—also known as continuous flow intersections.


SUMMARY REPORT

Evaluation of Sign and Marking Alternatives for Displaced Left-Turn Lane Intersections

FHWA Publication No.: FHWA-HRT-08-071

FHWA Contact: Joe Bared, HRDS-05, (202) 493-3314, joe.bared@fhwa.dot.gov

This document describes research conducted by the Federal Highway Administration (FHWA) to support guidance on the signing and marking of displaced left-turn lane intersections (DLT)—also known as continuous flow intersections (CFI).

Introduction

In recent years, the FHWA has advocated certain novel intersection designs as a means to promote intersection safety while meeting the often conflicting demands to increase capacity, decrease travel time, and minimize the cost of new infrastructure. One of these designs, the DLT, is in the early stages of deployment in the United States.

The DLT is an at-grade intersection that is intended to support high-traffic flow where there is a large volume of left turns and heavy through volumes. Its design permits the use of two- or three-phase traffic signals at the junction of two roads, while still providing at-grade protected left-turn movements. Two-phase signals are enabled by having left-turning traffic cross over opposing lanes to the left side of the roadway in advance of the main intersection. The turn onto the cross street can then be made at the same time as the opposing through movements on the originating road. This eliminates possible conflicts with the through movement. Timing of the signals at the crossover points and at the main intersection can help to ensure that vehicles, whether through or turning, stop just once at the intersection. Figure 1 shows the direction of travel for left-turn traffic (yellow arrows) and opposing through traffic (blue arrows) at a partial DLT in Baton Rouge, LA. A partial DLT is designed with two opposing displaced left-turn bays on the major road, while the left-turn traffic of the cross street is kept at the main intersection.

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

www.tfhrc.gov

The DLT is an at-grade intersection that is intended for areas where there is a large volume of left turns and heavy through volume. The DLT design uses two- or three-phase traffic signals at the junction of two roads, while still providing at-grade protected left turns. In DLT intersections, left-turning traffic crosses over opposing lanes to the left side of the roadway well before the main intersection. Left-turning vehicles then travel on a new roadway parallel to the opposing lanes and execute the left turn with a signal simultaneously with the through traffic at the main intersection. Timing of the signals at the crossover points and at the main intersection helps to ensure that vehicles, whether through or turning, stop just once at the intersection.

Several studies have shown the benefits of the DLT design over other signalized intersection designs in terms of increased capacity and efficiency of land use. Because a DLT uses a two-phase signal, it results in less delay, fewer pollutants, and lower fuel consumption than conventional at-grade intersections with three or more signal phases.

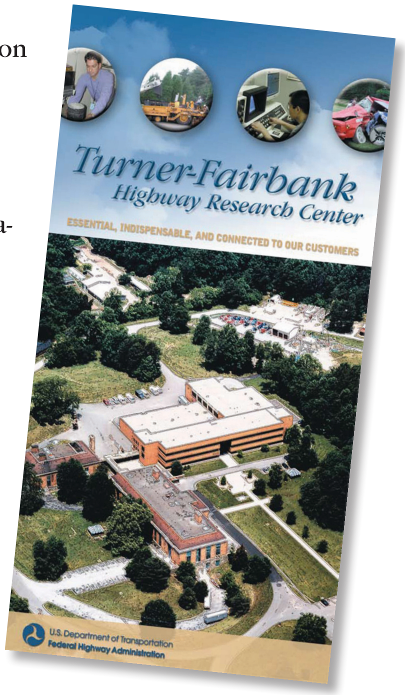
The summary report is available at www.tfhrc.gov/safety/intersect.htm. Printed copies also are available from the FHWA Product Distribution Center.

Turner-Fairbank Highway Research Center Brochure
Publication No. FHWA-HRT-08-066

FHWA's Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA, is the Nation's premier highway research and development facility. TFHRC coordinates and conducts an ambitious program of innovative highway research and development to address critical needs of the national highway system. This brochure provides an overview of TFHRC's research and development offices and a historical timeline.

As a national leader in transportation research, FHWA works with the U.S. Department of Transportation and partners in State and local government, industry, and professional organizations to develop and deliver a comprehensive nationally coordinated research and technology program. FHWA also collaborates with other institutions, such as the National Academy of Sciences, university transportation centers, national laboratories, and international highway research laboratories and communities to support this national transportation research program.

At TFHRC, FHWA's engineers, scientists, and psychologists conduct advanced and applied research to create innovative solutions that improve Americans' quality of life. By developing advanced technologies and techniques and implementing systems and simulation tools, TFHRC focuses on preventing congestion, improving mobility and roadway safety, reducing highway crashes and related fatalities, and improving infrastructure performance. Through FHWA's three research and development offices—Infrastructure, Safety, and Operations—along with the Exploratory Advanced Research Program, the agency is working to meet the transportation challenges of today and the future.



The brochure is available at www.tfhrc.gov/about/brochure.htm. Printed copies are available from the FHWA Product Distribution Center.

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

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Date	Conference	Sponsors	Location	Contact
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September 13–17, 2009	2009 International Conference on Ecology & Transportation	Minnesota Department of Transportation, Center for Transportation and the Environment at North Carolina State University, Federal Highway Administration (FHWA), U.S. Fish & Wildlife Service, U.S. Forest Service, Defenders of Wildlife	Duluth, MN	James Martin 919-515-8620 jbm@ncsu.edu www.icoet.net/ICOET2009.asp
September 24–25, 2009	ARTBA Public Private Ventures Conference	American Road & Transportation Builders Association (ARTBA)	Washington, DC	Allan Freedman 202-289-4434, ext. 205 afreedman@artba.org www.artba.org/meetings_events /meetings_index.htm
October 4–7, 2009	APTA 2009 Annual Meeting	American Public Transportation Association (APTA)	Orlando, FL	Pamela Boswell 202-496-4803 pboswell@apta.com www.apta.com
October 27–30, 2009	AMPO 2009 Annual Conference	AMPO and Chatham County - Savannah Metropolitan Planning Commission	Savannah, GA	Nicole Waldheim 202-296-7051 nwaldheim@ampo.org www.ampo.org/content/index .php?pid=200
November 5–6, 2009	4th Asphalt Shingle Recycling Forum	Asphalt Roofing Manufacturers Association, Owens Corning, FHWA	Chicago, IL	Audrey Copeland 202-493-0341 audrey.copeland@dot.gov www.shinglerecycling.org/content /asphalt-shingle-forum-home
November 10–14, 2009	86th Congress of Cities & Exposition	National League of Cities	San Antonio, TX	Michelle Lynch 202-626-3102 conference@nlc.org www.NLCCongressofCities.org
November 10–15, 2009	5th Congress on Forensic Engineering	American Society of Civil Engineers	Washington, DC	Michael Drerup 212-895-8105 mdrerup@exponent.com http://content.asce.org /conferences/forensics2009 /index.html
November 12–13, 2009	Developing a Research Agenda for Transportation Infrastructure Preservation and Renewal	Transportation Research Board	Washington, DC	Matthew Miller 202-334-2966 mamiller@nas.edu Tom Palmerlee 202-334-2966 tpalmerlee@nas.edu www.TRB.org/conferences/2009 /Infrastructure


Gregory Kostyniuk

October
27–30, 2009

Arnold and Mabel Beckman
Conference Center of
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Irvine, CA

Register at **www.trb.org/calendar**, then scroll to October 2009 and click on the conference title.

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- **Crime and personal security:** gender differences and crime, harassment, security in various travel modes, impact of design features on crime prevention and reduction
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