U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

List

The technologies and innovations (T&Is) described below are ones that the Federal Highway Administration (FHWA) believe warrant special attention.

This list is not intended to include all T&Is available. Numerous T&Is are being developed, but are not yet ready to be marketed in the field. In addition, many T&Is are considered good concepts, practices, and/or success stories that should continue to be shared. This initial list is intended to be a living list. A process will be developed for reviewing and updating these T&Is.

511 Traveler Information—An easy-to-remember three-digit telephone number available to State and local transportation agencies nationwide so that they can readily provide information and highway and transit conditions to travelers by telephone. Contact: Bob Rupert, 202–366–2194.

Asset Management Guide—The guide illustrates asset management principles and identifies techniques and methods for adopting the decisionmaking framework in transportation agencies. Contact: Stephen Gaj, 202–366–1559.

Augered Piles—The technology is characterized by the drilling of a hollow-stem auger into the ground, pumping grout or concrete into the hole, and installing reinforcement in the pile. This eliminates the need for a temporary casing. Contact: Silas Nichols, 410–962–2460.

Border Wizard—A PC-based software model that accurately simulates all cross-border movements of autos, buses, trucks, and pedestrians, using customs, immigration, and security procedures. Contact: Mike Onder, 202–366–2639.

Dispute Resolution Guidance for Environmental Streamlining—These procedures present strategies for interagency collaborative problem solving during the transportation development and environmental review process. Contact: Ruth Rentch, 202–366–2034.

Expanded Polystyrene (EPS) Geofoam—Lightweight material that can be used as fill behind walls and other support structures. Contact: Peter Osborn, 410–962–0702.

FHWA Traffic Noise Model (TNM), Version 2.1—By improving the ability to predict noise impacts in the vicinity of highways, this model improves the quality of project development decisions. Contact: Bob Armstrong, 202–366–2073.

Highway Economic Requirements System, State Version—A software model that is designed to evaluate the implications of alternative programs and policies on the conditions, performance, and user cost levels associated with highway systems. Contact: David Winter, 202–366–4631.

Improved Decisionmaking Using Geographic Information Systems—A software program that allows for manipulation, analysis, and display of geographically referenced data. Contact: Mark Sarmiento, 202–366–4828.

Interagency Funding Guidance for Environmental Streamlining—Guidance provides transportation and resource agencies with options for using Federal funds to support Federal resource agency coordination for streamlining environmental reviews. Contact: Ruth Rentch, 202–366–2034.

Intelligent Transportation Systems (ITS) SpecWizard—A software tool that can help transportation agencies write specifications for the National Transportation Communication for ITS Protocol (NTCIP) standards-based ITS equipment. Contact: Jason Hedley, 202–366–4073.

Load and Resistance Factor Design and Rating of Structures—An AASHTO Load and Resistance Factor Design (LRFD) and Rating (LRFR) bridge specification provides for more uniform levels of safety, which should lead to superior serviceability and long-term maintainability. Contact: Firas Ibrahim, 202–366–4598.

Pavement Smoothness Methodologies—The new pavement smoothness specification covers smoothness test methods, smoothness equipment specifications, and equipment-certification programs. Contact: Mark Swanlund, 202–366–1323.

QuickZone—A user-friendly computer software tool for estimating and analyzing length of queues and delays in work zones. Contact: Scott Battles, 202–366–4372.

Red Light Cameras—The traditional enforcement of violations for running red lights is automated by using camera systems at light-controlled intersections that detect an offending motorist, capture an image of the license plate, and issue a citation by mail. Contact: Hari Kalla, 202–366–5915.

Roundabouts—A circular intersection that requires entering vehicles to yield to existing traffic in the circulatory roadway. Contact: Hari Kalla, 202–366–5915.

Rumble Strips—Shoulder rumble strips are continuous grooved indentations in roadway shoulders that provide both an audible warning and a physical vibration to alert drivers that they are leaving the roadway. Contact: Dick Powers, 202–366–1320.

Safe Speeds in Work Zones—Two technologies that can improve safety in work zones are portable speed limit signs that automatically display the safe speed based on traffic conditions and the nature of the roadwork, and feedback displays that show the speed of approaching vehicles. Contact: Davey Warren, 202–366–4668.

Transportation, Economics, and Land Use System (TELUS)—This information-management and decision-support system helps State DOTs and metropolitan planning organizations prepare their annual transportation improvement programs and statewide transportation improvement programs. Contact: Fred Ducca, 202–366–5843.

AASHTO Technology Implementation Group Approved Technologies

Accelerated Construction—This undertaking promotes creative techniques to reduce construction time and enhance quality and safety. Contact: Dan Sanayi, FHWA, dan.sanayi@fhwa.dot.gov.

Air Void Analyzer—The air void analyzer can be used to provide real-time evaluation for measuring air content, specific surface, and the spacing factor of fresh portland cement concrete. Contact: John Wiakowski, Kansas DOT, johnw@ksdot.org.

Fiber-Reinforced Polymer—This material can be used to repair cracks in overhead sign supports by wrapping the support with the fiber-reinforced material. Contact: Paul Wells, New York State DOT, pwells@gw.dot.state.ny.us.

Global Positioning System (GPS) Surveying—The GPS uses satellites that transmit signals continuously; it has many highway applications, including surveying pavement conditions and inventorying highway assets. Contact: Charlie Brown, North Carolina DOT, charliebrown@dot.state.nc.us.

Ground-Penetrating Radar—Vehicle-mounted, ground-penetrating radar can be used to collect information about underlying highway pavement layers without incurring the time and labor costs and traffic delays associated with traditional methods of drilling for core samples. Contact: Mike Murphy, Texas DOT, mmurphy@dot.state.tx.us.

Highway Rail Warning System—A low-cost active warning system used at low-volume, highway-railroad at-grade intersections, most often mounted on standard crossing poles, and the technology is solar battery-powered with wireless communications between the device and the locomotive. Contact: Dave Huft, South Dakota DOT, dave.huft@state.sd.us.

ITS Technologies in Work Zones—The use of ITS technologies in work zones, such as ramp-metering systems, intrusion alarms, and queue-detection information (sensors/cameras), is aimed at increasing safety for workers and road users and ensuring a more efficient traffic flow. Contact: Doug Rose, Maryland State Highway Administration, drose@sha.state.md.us.

Prefabricated Bridge Elements and Systems—These systems minimize traffic impacts of bridge construction projects, improve construction work-zone safety, and make construction less disruptive for the environment by minimizing the need for lane closures, detours, and use of narrow lanes. Contact: Mary Lou Ralls, Texas DOT, mralls@dot.state.tx.us.

Thermal Imaging Safety Screening System—The system allows an operator at a weigh station to view the relative temperatures of brake drums through the wheel rims of commercial vehicles, using infrared images to detect whether brakes are functioning properly. Contact: Gary Hoffman, Pennsylvania DOT, ghoffma@dot.state.pa.us.

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Priority, Market-Ready Technologies and Innovations

511 Traveler Information

Problem: Access to 511 traveler information systems remains limited

Telephone services for travelers provide real-time information about work zones, traffic incidents, and other causes of congestion. They allow travelers to make more informed decisions about their travel routes or modes, and increase safety by helping motorists avoid areas with congestion or incidents. The U.S. Department of Transportation (USDOT) petitioned the Federal Communications Commission in 1999 for a three-digit dialing code for travel information, and was assigned 511 in 2000. In 2001, the Cincinnati, OH area became the first in the country to use 511 for travel information.

Why is 511 needed?
Before the 511 dialing code was assigned for travel information, more than 300 different telephone numbers provided travel information in the United States. A test drive in 1999 showed that 11 different numbers were required to access travel information on a trip from Washington, DC to New York, NY. As 10-digit phone numbers and new area codes proliferate, a single, easy-to-remember number will help local and interstate travelers and shippers avoid delays and save time.

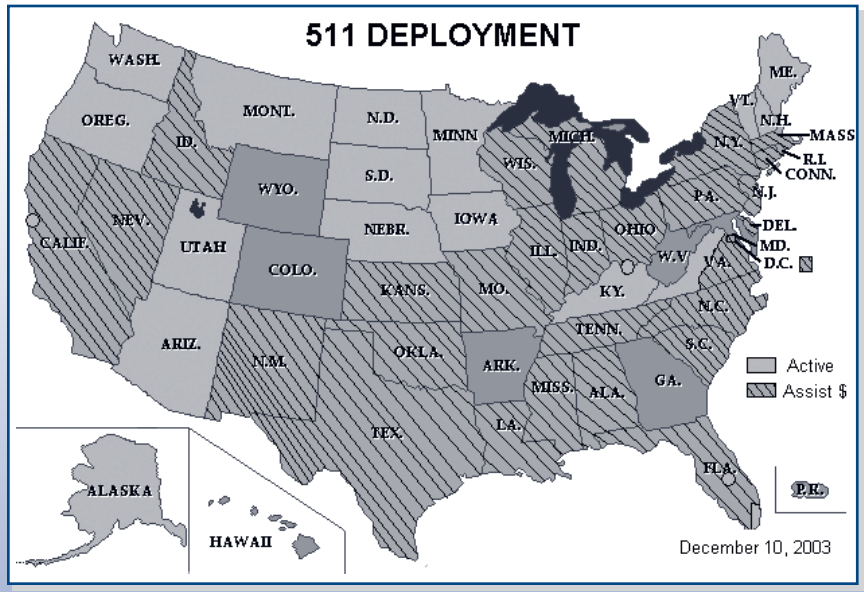
How widespread are 511 services?
More than 50 million Americans, or 17 percent, now have access to 511 services. Since 2001, systems have been deployed in all or parts of Alaska, Arizona, California, Florida, Iowa, Kentucky, Maine, Minnesota, Montana, Nebraska, New Hampshire, North Dakota, Oregon, South Dakota, Utah, Vermont, Virginia, and Washington. Other States are planning to implement 511 systems.

Putting It in Perspective

- Nearly 650,000 calls were made to 511 in October 2003, bringing the total number of 511 calls to more than 10 million.
- Less than 20 percent of Americans have access to 511 services.
- By 2005, more than half the country is expected to have 511 access.

Solution: Increasing access to 511 services will help travelers make better decisions

The USDOT is facilitating national implementation of 511 systems to make real-time traveler information more widely available to motorists. It is working with a 511 Deployment Coalition that includes the American Association of State Highway and Transportation Officials, Intelligent Transportation Society of America, and American Public Transportation Association.



511 deployment across the United States

What Federal assistance is available for implementing 511 systems?
The Federal Highway Administration (FHWA) offers grants of up to $100,000 to States to develop 511 implementation plans. Forty-four States have received grants. States that already have plans can use the funds to cover the costs of converting to 511 or developing 511 services. FHWA offers technical assistance through its division offices in every State. FHWA also is funding a model deployment program in Arizona.

How do States fund 511 programs?
Implementation expenses for 511 systems, like other traveler information services, are eligible for regular Federal-aid highway funding. Local or State transportation funds also are used to pay for 511 systems, and in general, are the only funds used to pay for day-to-day system operations.

How does a typical 511 program work?
A 511 system relies on intelligent transportation systems technologies to collect and disseminate traveler information. Callers access the service by dialing 511 from any telephone. They hear a menu of available information on highways and public transit and indicate their choices by using the telephone's touch pad or, for systems with voice recognition technology, by voice. Some 511 systems offer premium services such as personal routing instructions or reservation services, which may involve additional charges.

Successful Applications: Research shows 511 increases use of traveler information services

Research indicates that public demand and use of telephone services for traveler information increase when systems use 511 instead of other numbers. Systems that have converted existing telephone numbers to 511 have experienced a 300–500 percent increase in call volume.

One study showed that 45 percent of San Francisco, CA travelers who received information from the area's Travel Advisory Telephone System changed their travel plans, compared to 25 percent of travelers altering their plans based on television or radio broadcasts.

Benefits

- Provides an easy way to obtain travel information anywhere in the country.
- Helps travelers make better decisions on travel routes and modes.
- Promotes safety by directing motorists away from incidents and congestion.

Additional Resources

The 511 Deployment Coalition has developed quality and service guidelines for 511 systems. The guidelines and other tools for 511 deployment are available at **www.fhwa.dot.gov/trafficinfo/511.htm**.

For more information, contact:

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U.S. Department of Transportation
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Priority, Market-Ready Technologies and Innovations

Asset Management Guide

Problem: Transportation agencies need a new management approach for a new era

Since interstate system construction has been completed, the emphasis has shifted from "build it" to "make it perform." Transportation agencies are under pressure to show improvements in performance and accountability for funding decisions.

Transportation Asset Management (TAM) provides the tools and structure to set goals, identify priorities, improve processes, and measure results to demonstrate improved performance. By focusing on the performance of the transportation system, agencies will be able to increase customer satisfaction.

What is transportation asset management?
TAM is a strategic approach that maximizes the benefits from resources used to operate, expand, and preserve the transportation infrastructure. TAM is not a software or database system, but a decisionmaking process for allocating resources in terms of user benefits. It is a way of thinking that enables agency leadership to view the big picture before deciding how to deploy resources.

How does it work?
TAM relies on tools and information to analyze tradeoffs among investment options. This decisionmaking process recognizes that transportation assets have a user aspect in addition to a physical, or engineering, dimension. The focus is on system performance rather than on how much money is spent or how many miles of roadway are improved.

Putting It in Perspective

- The Nation's highways are valued at more than $1.75 trillion.
- Nearly $130 billion is invested annually to preserve and improve the highway system.
- TAM can help ensure that highway investment results in improved system performance.

Solution: Guide explains TAM techniques

The American Association of State Highway and Transportation Officials (AASHTO) has developed a *Transportation Asset Management Guide* for transportation agency leaders.

The guide explains TAM techniques and offers examples of good practice in four areas—policy development; planning and programming; program delivery; and information, analysis, and performance monitoring. The guide includes a self-assessment tool to help agencies review their asset management practices and identify opportunities for improvement.

How can agencies learn more about TAM?
The Federal Highway Administration (FHWA) has developed a one-day National Highway Institute (NHI) course to familiarize senior managers with the concepts, principles, and techniques outlined in the *Transportation Asset Management Guide*.

The course includes presentations, discussions, and exercises, including a session on completing and interpreting the results of the self-assessment tool. It offers a useful way to organize thinking about TAM issues, develop a consensus among managers on their agency's strengths and improvement areas, and structure an agenda for TAM implementation.

Successful Applications: Agencies are already moving toward an asset management approach

Many building blocks for TAM already exist in transportation agencies. Pavement management, bridge management, and information management systems provide the inputs necessary for TAM analysis. Most agencies have begun the transition to TAM-based thinking through performance-based management and strategic planning. The guide and training course are helping agencies build on steps they have taken toward a TAM approach.

The necessary computing power, data, and analytical tools to make TAM work are available, and agencies are using TAM to address the challenges they face in the 21st century. Agencies are making decisions involving tradeoffs among preserving what is in place, adding new capacity, improving system operations, enhancing environmental quality, improving safety, and ensuring security.

Benefits

- Involves strategic way of thinking that considers long-term consequences of investments.
- Focuses on way of doing business that is performance driven, focused on customer satisfaction, and oriented to return on investment.
- Uses new analytical tools and new ways of applying old tools to better integrate data and support decisionmaking.

Additional Resources

More information on TAM and the *Transportation Asset Management Guide* are available at **http://assetmanagement.transportation.org**.

Information on the NHI TAM training course is available at **www.nhi.fhwa.dot.gov/coursedesc.asp?coursenum=1130**.

For more information, contact:

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U.S. Department of Transportation
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Augered Piles

Problem: Bridge deficiencies create safety and mobility concerns

As the Nation's highway infrastructure continues to deteriorate, bridge deficiencies adversely impact mobility, safety, and economic development. Many State departments of transportation (DOT) are struggling to maintain an acceptable schedule of bridge maintenance, repair, and replacement. In 2002, 14 percent of all bridges that are 6.1 meters (20 feet) or longer were considered structurally deficient. Restrictions on vehicle weights as a result of these deficiencies may lead to certain vehicles using alternate routes, thus lengthening travel times and reducing efficiency. At the same time, traffic congestion continues to increase.

To mitigate the problems associated with deficient bridges and increased traffic, bridges throughout the country must be replaced or widened, and lane capacity will need to be added. Improving the Nation's infrastructure will require a significant investment. To mitigate congestion, construction schedules must be accelerated to reduce impact to the public and be economically stringent to provide funds for more projects. To achieve these goals, foundation design and construction must identify more efficient and cost-effective methods for supporting structures.

Putting It in Perspective

- Twenty-seven percent of the Nation's bridges are structurally deficient or functionally obsolete.
- One in every five highway projects is considered "traffic sensitive."
- From 1991 to 2001, vehicle travel grew at a rate seven times higher than did added roadway capacity.
- The cost of repairing all U.S. bridge deficiencies is estimated at $136 billion.

Solution: Augered pile foundations offer a low-cost alternative

What are augered piles?
Augered piles are a deep-foundation element characterized by drilling a hollow-stem auger into the ground to form the pile's diameter. Sand-cement grout or concrete is pumped into the hole as the auger is removed, eliminating the need for temporary casing or slurry. After the auger is removed, reinforcement is installed. Typically, augered piles are grouped based on the type of equipment used to install them. The three most common types are Auger Cast-in-Place (ACIP), Continuous Flight Auger, and ACIP-Displacement. Augered piles generally are available in 304.8- to 914.4-millimeter (12- to 36-inch) diameters and typically extend to depths of 18.3–21.3 meters (60–70 feet). In some cases, augered piles have been installed to depths of more than 30.5 meters (100 feet).

Why use augered piles?
Augered piles can be installed quickly and inexpensively, and are a viable foundation alternative to driven piles or drilled shafts for certain applications. Augered piles can support lateral earth and critical and noncritical structures, and can be used in ground improvement applications.

Typical highway project applications for augered piles include structure support for new bridges, bridge widening, sound wall foundations, column support for embankment construction, and secant walls for lateral earth support. Augered piles are a good deep-foundation solution in areas that are environmentally sensitive or require minimal disturbance to human activity.

Successful Applications: States use augered piles on various projects

Approximately 10 State DOTs and the Federal Highway Administration (FHWA) Federal Lands Highway Department have approved the use of augered piles on a project-specific basis.

In the mid-1990s, the Texas DOT began using ACIP piles as foundations for sound walls in the Houston, TX area. The State successfully completed construction of a bridge in Crossley, TX, supporting the abutments on 69 46-centimeter (18-inch) diameter ACIP piles. Pile lengths were as long as 20.4 meters (67 feet). To handle lateral loads, some of the piles were constructed on a 4-to-1 batter. Texas DOT is planning to construct a bridge that will be founded on ACIP piles in Dallas, TX.

To reduce vibrations that might have caused potential damage to an active metro subway line, the District of Columbia DOT used ACIP displacement piles to construct the foundation elements for a portion of a replacement structure. The piles were installed under low headroom conditions and created minimal vibrations, which reduced disturbances to the overhead metro line.

Benefits

- Rapid installation accelerates foundation construction, which reduces project schedules.
- Automated monitoring equipment provides real-time quality control.
- Suitable for low headrooms or confined spaces.
- Limited installation noise and vibration for sensitive urban environments.

Additional Resources

To learn more, visit
www.fhwa.dot.gov/resourcecenter/index.htm.

For more information, contact:

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U.S. Department of Transportation
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Priority, Market-Ready Technologies and Innovations

Border Wizard

Problem: Border crossings suffer from growing congestion

Increasing traffic volumes and delays in processing commercial vehicles have led to significant congestion at land-based border crossings with Canada and Mexico. In addition, a new national emphasis on security calls for more efficient and secure border crossings. Balancing the needs for security and trade efficiency, as well as coordinating improvements to ports of entry, can be a tremendous challenge for U.S. agencies involved in border activities.

Where are truck-processing delays most significant?
In 2001, the Federal Highway Administration (FHWA) surveyed seven ports of entry that handle more than 60 percent of U.S. truck trade with Canada and Mexico (source: *Freight News* June 2002). The study found that the time needed to process commercial vehicles entering the United States was significantly longer than that for departing vehicles at nearly every location. It also showed that delay times at southern borders exceeded those at northern borders, mostly because of controlled substance and illegal immigration inspections at southern crossings.

Putting It in Perspective

In 2001, before the September 11 tragedy, a truck traffic survey at seven U.S. ports of entry found that:

- Average inbound travel time was 26.8 minutes, but for 95 percent of trucks it was more than 70 minutes.
- Average outbound travel time was 14.2 minutes.
- Border crossing delays were less predictable than those observed on urban roadways in another FHWA study.

Solution: Border Wizard analyzes facility and operational needs at crossings

FHWA, in conjunction with the General Services Administration (GSA), Customs and Border Protection and Immigration and Customs Enforcement, developed a tool called Border Wizard to coordinate improvements to border crossings that increase security, traffic throughput, and trade efficiency. Border Wizard is maintained and distributed by GSA under an agreement of the Border Station Partnership Council, consisting of the four developing agencies.

What is Border Wizard?
Border Wizard is a computer-based model that simulates cross-border movements of autos, buses, trucks, and pedestrians. It can simulate all Federal inspection activities—including customs, immigration, motor carrier, and security procedures—at any land border station to determine infrastructure, facility, and operational needs to ensure safe and secure operations. It is also intended to be linked to other traffic modeling and planning tools used by States and metropolitan planning organizations. Analysis is currently

underway to determine Border Wizard's effectiveness as an integrated tool for transportation planning purposes.

How does Border Wizard work?
Port facility and operational data are entered into the model using data entry screens. Sample facility data include layout of the station and number of inspection booths, parking spaces, and warehouse slips. Operational data include kinds of equipment used, Federal and contractor personnel conducting inspections, and processes in use by all border inspection agencies, including Customs, Immigration and Motor Carrier Safety. Border Wizard can then graphically construct or modify border station design and operations.

Successful Applications: Border Wizard helps save on capital investments

Since 2002, more than 60 ports of entry have used Border Wizard for project justification and evaluation. GSA estimates that between $5 million and $10 million has been identified as unnecessary capital investments at the 10 ports of entry for which Border Wizard was originally used as an analysis tool. For three additional ports scheduled for major capital investments, GSA projects that avoided capital investment will be between $15 million and $30 million.

Customs and Border Protection has used Border Wizard to evaluate proposed inspection methods and routing in commercial operations at both northern and southern border stations. In addition, Immigration now collects data at all major border stations in preparation for using Border Wizard to evaluate inbound and outbound inspection operations and assess the effects of security changes at U.S. borders.

In the future, Border Wizard will allow users to run studies on multiple border stations simultaneously and compare their effects on each other. This will be useful in analyzing proposed border station development and in determining when an area will reach capacity and require a new border station to be built. The dispersion of traffic to the new facility can also be estimated.

Benefits

- Accurately simulates cross-border movements.
- Helps save on capital investments at ports of entry.
- Can be used to evaluate prospective or existing facilities.

Additional Resources

Border Wizard is still undergoing analysis and testing to determine its fit with other traffic modeling and planning tools. It is available for purchase through GSA in Fort Worth, TX. For purchasing information, contact Don Cobb at 817–978–7210.

For more information, contact:

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U.S. Department of Transportation
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Priority, Market-Ready Technologies and Innovations

Dispute Resolution Guidance for Environmental Streamlining

Problem: Disputes that arise during the transportation development process can cause delays

As a transportation project moves through the project development and environmental review phases, conflicts may arise among the various Federal and State agencies involved in the process. The time and resources required to resolve these conflicts can add significant costs to the project and prevent it from being completed in a timely manner.

Why do disputes occur?
Disputes may arise over competing interests, such as conservation versus development; different needs, such as mobility and air quality; and the range of influences under which the project is carried out, such as political, statutory, and philosophical. Competing priorities of resource impacts, mitigation, and desired outcomes come into play.

What types of disputes occur?
Information disputes that can cause delays commonly involve disagreements on lack of data, data interpretation, underlying planning assumptions, and agency jurisdiction. Disputes also can be related to insufficient agency resources, an agency's failure to fulfill a commitment, conflicts over various agencies' missions and mandates, and interpretation of terms used in the planning and review process.

Putting It in Perspective

The Federal Highway Administration's (FHWA) National Dispute Resolution System includes:

- Dispute resolution guidance, *Collaborative Problem Solving: Better and Streamlined Outcomes for All*.
- U.S. Department of Transportation (USDOT) National Procedures for Elevating Highway and Transit Environmental Disputes (USDOT Order 5611.1A).
- Roster of qualified neutrals experienced in the transportation development process.
- Facilitated interagency discussion workshops to improve transportation project development and environmental review through collaborative problem solving.

Solution: Dispute resolution guidance offers framework for managing conflict

FHWA worked with the U.S. Institute for Environmental Conflict Resolution, Federal transportation and resource agencies, and State departments of transportation to develop a guidance document, *Collaborative Problem Solving: Better and Streamlined Outcomes for All*.

What is the guidance designed to do?
This guidance is designed to assist agencies as they plan transportation projects. It presents strategies for managing conflict and identifying issues that may arise during project development and environmental process reviews under the National Environmental Policy Act (NEPA) and related laws.

The guidance, one element of FHWA's national dispute resolution system, is not an absolute prescription, but a source of problem-solving options. It can help agencies implement a coordinated environmental review process that streamlines unnecessary delays for highway and transit project consultation.

What strategies does the guidance cover?
The document outlines strategies for environmental streamlining and dispute resolution and recommends several guiding principles:

- Engage all relevant agency representatives early, actively, and continually in collaborative problem solving during transportation planning and project review processes.
- Improve negotiation and problem-solving skills of agency staff through training and coaching.
- Attempt to resolve disagreements at the earliest stage possible and at the lowest appropriate organizational level.
- Seek resolution first by focusing on how to meet agency interests and needs in the context of existing laws and regulations.
- Take advantage of experienced facilitators and mediators to assist agencies in designing conflict management processes and resolving challenging disputes.
- Make effective use of high-level authorities as appropriate for negotiating impasses or resolving high-level issues.
- Educate each other regarding each agency's legal authorities, and structure collaborative processes to respect those authorities.

Successful Applications: States use environmental guidance to streamline processes

Florida has adopted a strategy for incorporating environmental factors into its long-range planning process, the Efficient Transportation Decision Making (ETDM) Process. The ETDM process will link land use, transportation, and environmental resource planning through early and continuous agency, general public, and Native American involvement in planning, project development, and environmental decisions. The process will take advantage of the Florida geographic data library (containing more than 400 data fields), and will include exchange of plans, programs, data, and information, including electronic comments. ETDM will replace sequential agency actions with concurrent agency actions and public involvement.

Oregon is defining a level of environmental review during planning that allows regulatory and resource agencies to provide input at various key points in the NEPA process. This is known as CETAS, or the Collaborative Environmental and Transportation Agreement for Streamlining.

Indiana developed streamlined environmental procedures to bring the NEPA process into early transportation planning and decisionmaking. The procedures include initiating major planning corridor studies as Environmental Assessments (EAs), thus engaging resource agencies in the developing purpose and need, and in screening preliminary alternatives. If the project involves significant impacts, a Notice of Intent is issued to develop an Environmental Impact Statement (EIS). EIS project development then begins where EA project development ended, ensuring a seamless decisionmaking process. This streamlined process will eliminate duplication of effort between planning and NEPA studies, resulting in more efficient decisions.

Benefits

- Prevents unnecessary delays in developing transportation projects.
- Encourages collaborative decisionmaking and coordination among agencies.
- Resolves disputes early in the process.
- Builds trust and respect among agencies.

Additional Resources

Collaborative Problem Solving: Better and Streamlined Outcomes for All is available at **http://environment.fhwa.dot.gov/strmlng/adrguide/index.htm**.

For more information, contact:

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Expanded Polystyrene (EPS) Geofoam

Problem: Highway capacity is insufficient to meet growing demand

Every year in the United States, traffic congestion results in 5.7 billion person-hours of delay; for each person, that delay averages 36 hours per year. In 1997, the individual cost of congestion exceeded $900 per driver, and total estimated costs were more than $72 billion in lost wages and wasted fuel. Highway congestion continues to grow as vehicle travel increases and the Nation's bridges and roads deteriorate.

To help alleviate this growing congestion, capacity on the Nation's highways and major roads must be expanded. In many circumstances, however, roadway embankment widening or new alignments may require construction over soft or loose soils that are incapable of supporting increased loads. Embankment construction projects must identify innovative materials and construction techniques to accelerate project schedules by reducing vertical stress on the underlying soil.

Putting It in Perspective

- One in every five highway projects is considered "traffic sensitive."
- Two out of every five urban interstate miles are considered congested.
- Traffic delays have more than tripled in the past 20 years.
- By 2020, the Nation's population is expected to grow by 16 percent, and vehicle travel is expected to increase by 42 percent.

Solution: Get in, get out, and stay out with EPS Geofoam

What is EPS Geofoam?
EPS Geofoam is a lightweight, rigid foam plastic that has been used around the world as a fill for more than 30 years. EPS Geofoam is as much as 100 times less dense than soil, while alternate lightweight fills are approximately 2–3 times less dense. This extreme difference in density, compared to other materials, makes EPS Geofoam an attractive fill. Because it is a soil alternative, EPS Geofoam embankments can be covered to look like normal sloped embankments or finished to look like a wall.

What are the advantages of EPS Geofoam for highway construction?
EPS Geofoam can be used as an embankment fill to reduce loads on underlying soils, or to build highways quickly without staged construction. EPS Geofoam has been used to repair slope failures, reduce lateral load as fill behind retaining structures, accelerate construction on fill for approach embankments, and minimize differential settlement at bridge abutments.

Because EPS Geofoam only weighs 16 to 32 kilograms per cubic meter (1–2 pounds per cubic foot), large earthmoving equipment is not required for construction. After the material is delivered to the site, blocks easily can be trimmed to size and placed by hand. In areas where right-of-way is limited, EPS Geofoam can be constructed vertically and faced, unlike most other lightweight fill alternatives. It also can be constructed in adverse weather conditions.

Successful Applications: States' results demonstrate EPS Geofoam advantages

Many States have used EPS Geofoam in large and small highway projects:

The Texas Department of Transportation (DOT) is about to widen U.S. Interstate 10 (I-10) as it passes over an existing culvert in San Antonio, TX. In lieu of the previously designed solution to span the culvert with a drilled shaft supported by reinforced concrete slab, engineers will look to EPS Geofoam to reduce the load on the culvert. By using EPS Geofoam, engineers estimate significant time savings and a cost savings of approximately one-half the original designed solution.

After years of searching for a permanent solution to a failing slope problem on State Route 23A, the New York State DOT turned to EPS Geofoam. By replacing upper sections of the slide area, the State significantly reduced the driving forces that were causing the slide and successfully rehabilitated the roadway section.

Two large and high-profile jobs—I-15 in Utah and the Big Dig in Massachusetts—turned to EPS Geofoam to construct large embankment sections. EPS Geofoam helped the projects maintain extremely tight construction schedules that would not have allowed enough time for conventional embankment construction. Both projects illustrated the ease and speed with which EPS Geofoam can be constructed for highway embankments.

Benefits

- Accelerates foundation construction, which reduces project schedules.
- Saves money.
- Requires limited labor for construction.
- Exerts little to no lateral load on retaining structures.
- Can be constructed easily in limited right-of-way areas and in adverse weather conditions.

Additional Resources

To learn more, visit
www.fhwa.dot.gov/resourcecenter/index.htm.

For more information, contact:

Peter Osborn, FHWA Resource Center
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FHWA-HRT-04-053
HRTS-03/01-04(1M)E

U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

FHWA Traffic Noise Model®, Version 2.1

Problem: Traffic noise creates headaches for communities and motorists

Highway traffic noise has been a Federal, State, and local problem since before the first noise barrier was built in 1963. Emanating from vehicle engines, exhaust systems, and tires interacting with pavement, traffic noise affects the quality of life for nearby residents and businesses by drowning out conversations, disrupting sleep, and discouraging outdoor activities. Over the years, community and motorist concerns have fueled the push to improve noise measurement and modeling tools that help transportation agencies address the highway traffic noise problem.

Putting It in Perspective

- Between 1997 and 2001, nationwide costs for noise barriers averaged more than $124 million a year.
- As of 2001, 44 State departments of transportation (DOT) and the Commonwealth of Puerto Rico had constructed more than 2,947 linear kilometers (1,831 linear miles) of noise barriers at a cost of more than $2.5 billion (in 2001 dollars).

Solution: Traffic Noise Model predicts traffic noise impacts around highways

The Federal Highway Administration (FHWA) has developed the FHWA Traffic Noise Model (FHWA TNM), a state-of-the-art computer program for predicting noise levels in the vicinity of highways. It uses advances in acoustics and computer technology to improve the accuracy and ease of modeling highway traffic noise, including the design of efficient, cost-effective highway noise barriers.

How does the FHWA TNM differ from earlier noise-prediction software?
The FHWA TNM calculates traffic noise levels using new acoustical algorithms and newly measured emission levels for five standard vehicle types: cars, medium trucks, heavy trucks, buses, and motorcycles. Its flexible database includes more than 6,000 individual vehicle pass-by events, measured at 40 sites across the country.

The FHWA TNM models sound levels for locations with and without noise barriers. The FHWA TNM allows for analyses of noise from constant-flow and interrupted-flow traffic, and determines the effects on noise levels of different pavement types, graded roadways, rows of buildings, dense vegetation, and parallel noise barriers.

What are the potential cost savings?
The FHWA TNM provides a 1-decibel increase in accuracy over FHWA's previous prediction model. Nationwide, noise barriers average 3.6 meters (12 feet) high. A 1-decibel improvement in traffic noise prediction accuracy could reduce the barrier height needed to control noise by 0.6 meters (2 feet), generating a 16 percent savings in noise barrier program costs, so savings could total more than $19 million a year.

Benefits

- Improves accuracy of predicting traffic noise levels.
- Helps design more efficient noise barriers.
- Reduces program costs for noise barriers.

Additional Resources

The FHWA TNM is being distributed by the McTrans Center at the University of Florida at a cost of $695. The FHWA TNM package includes the executable code, the User's Guide, the Technical Manual, and a CD-ROM Trainer. The FHWA TNM may be ordered from McTrans at 352–392–0378, extension 242, Monday–Friday. The fax number is 352–392–3224.

For more information, contact:

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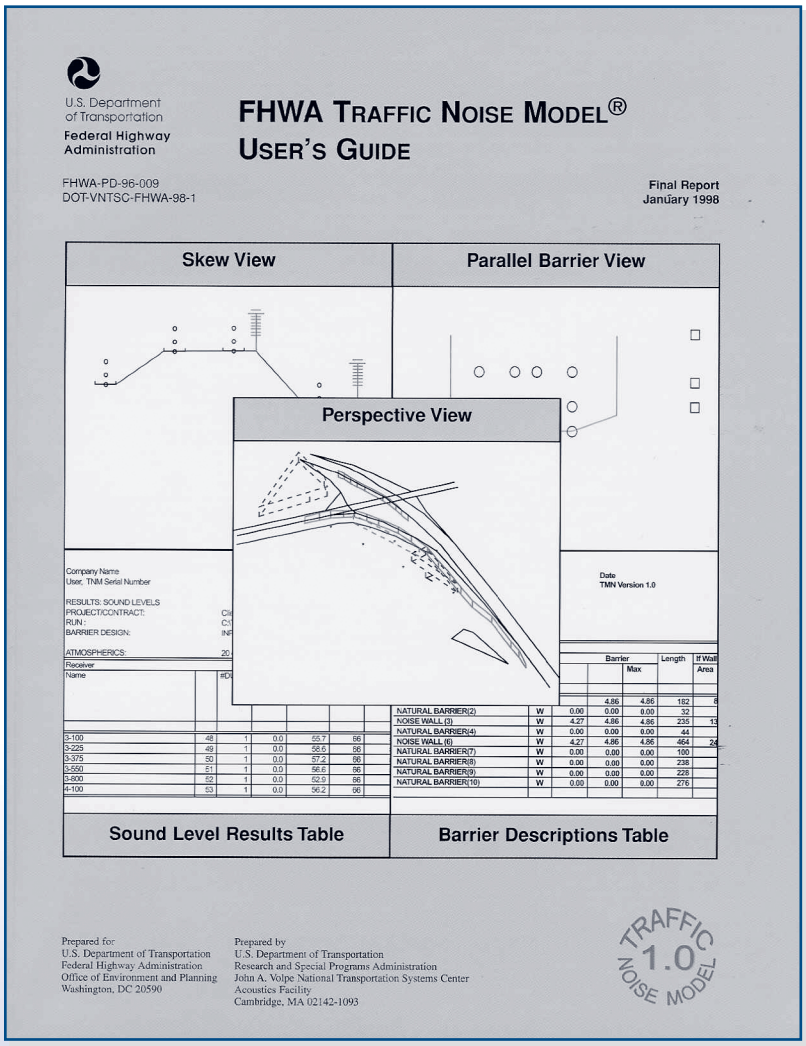

FHWA TNM User's Guide

FHWA-HRT-04-054
HRTS-03/01-04(1M)E

U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Highway Economic Requirements System, State Version

Problem: Transportation agencies need planning tools that help contain improvement costs while enhancing system performance

In the past, transportation agencies have had to rely on engineering applications for long-range planning and programming. However, many agencies are beginning to focus on system performance rather than simply on dollars spent or miles improved. This Transportation Asset Management approach has created a demand for planning tools that incorporate economic factors, especially user benefits and costs, in addition to traditional engineering considerations. Because existing engineering software packages were not designed specifically for managing transportation assets, they did not adequately address these agencies' changing needs.

To address this problem, the Federal Highway Administration (FHWA) developed the Highway Economic Requirements System, State Version (HERS-ST) from the national-level HERS program that FHWA has used since the early 1990s.

Putting It in Perspective

Transportation agencies need resources for:

- Long-range planning.
- "What if" analyses.
- Governmental Accounting Standards Board (GASB) 34 compliance.
- Congestion management.
- Needs assessment.
- Data management.
- Legislative decision support.

Solution: HERS uses engineering and economics to improve system performance

The concept of adapting the national-level HERS model for State use began when the State of Oregon recognized that HERS had great potential for Statewide planning, and created a version of HERS to meet their needs. FHWA then launched a HERS-ST pilot program to gauge State interest. The response was very positive—14 States are using HERS-ST.

What is HERS-ST?
HERS-ST is a user-friendly Microsoft® Windows® application that helps transportation agencies plan and schedule highway work, and determine future highway system needs. This software uses engineering principles to simulate future highway conditions and performance levels, and identify deficiencies. The program then applies economic criteria to select the most cost-effective mix of improvements for systemwide implementation.

How does it work?
HERS-ST accepts highway-section records input in the Highway Performance Monitoring System format. For each highway section, the model predicts future condition and capacity deficiencies, identifies alternative improvements to correct each deficiency, and determines a benefit-cost ratio for each potential improvement. To calculate benefits, the analysis considers the value of travel time, safety, vehicle operating costs, emissions, and highway agency costs. The model identifies the most economically attractive improvement for each section, and then determines the improvements to be implemented by comparing the benefit-cost ratios. HERS-ST can optimize highway investment given funding constraints or performance objectives specified by the analyst. The software allows users to view the analysis output spatially in a built-in Geographic Information System (GIS) view. HERS-ST users also can create customized charts and reports.

Successful Applications: Quantifying the impact of highway investments

HERS-ST can help a State maximize the return on its highway investments. Transportation agencies can use HERS-ST to estimate the impact of investment strategies on future system performance. HERS-ST will provide decisionmakers with information about the impacts of current and future highway improvements on agencies, highway users, and the environment.

In 2003, FHWA provided free onsite briefings and workshops on HERS-ST for nine States. In 2004, this onsite assistance will be expanded to include implementation support for States that need help to setup and run HERS-ST. FHWA can provide assistance in assembling the program input data, adjusting the software's various parameters and controls, understanding the output generated, and creating customized reports.

Benefits

- Improves system performance.
- Enhances customer satisfaction.
- Combines engineering and economics to maximize return on investment.

Additional Resources

FHWA will release a new version of the software in January 2004, along with a new user's guide and technical report. To learn more about HERS-ST, visit **www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.htm**. The Web site hosts a HERS-ST community of practice, where visitors can post questions and comments. The new software and user's guide also will be posted on the Web site.

For more information, contact:

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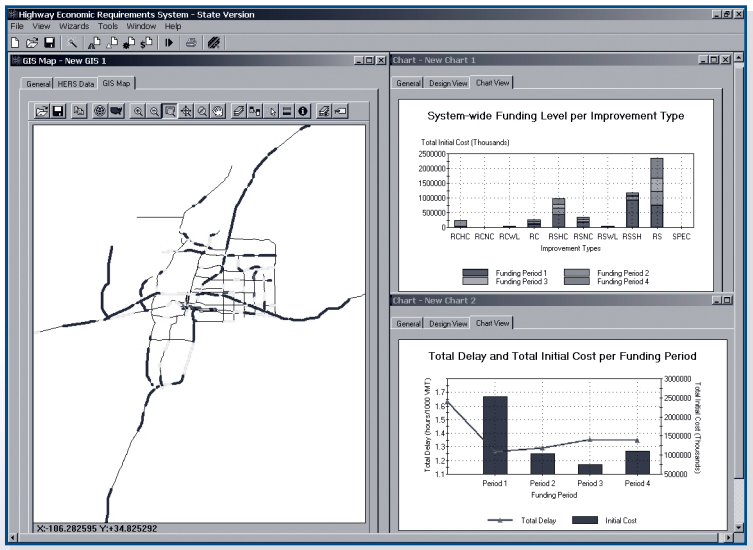


HERS-ST software image

FHWA-HRT-04-055
HRTS-03/01-04(1M)E

U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Improved Decisionmaking Using Geographic Information Systems

Problem: Integrating geographic information into the transportation decisionmaking process can be difficult

Transportation planners must incorporate a wide diversity of information into the planning process; however, this information often takes time to collect, is not centralized, and is not easily presentable. An accessible information tool would be very helpful in the planning, scoping, permitting, and evaluating processes associated with transportation decisionmaking.

Putting It in Perspective

By using GIS to bring together information more efficiently, transportation planners are in a better position to review, analyze, and understand the problems they are addressing. This efficiency can save time and money, and a better understanding of information can lead to improved decisionmaking.

Solution: Geographic Information Systems (GIS) can inform transportation planning

What is GIS?
GIS is a system of computer hardware and software that collects, stores, analyzes, and disseminates information about areas of the earth. While GIS often helps create maps, GIS can also maximize the quality and use of spatial data analysis to help answer questions of where, how far, how many, what size, and within what area.

Why is GIS useful?
GIS can offer significant advantages over conventional computer programs. It allows geographers to collate and analyze information much easier than is possible with traditional research techniques. GIS technology is a general tool that can be used across a wide range of transportation applications. It allows staff to visualize the spatial relationships among any geographically referenced features (such as clusters of highway crashes and roadway characteristics). It facilitates integration of different databases based on geographic proximity (for example, GIS technology can identify the total population residing within a metropolitan planning area, but outside the urbanized area). It also helps transportation staff present findings to policymakers and the general public using visually attractive and understandable thematic maps.

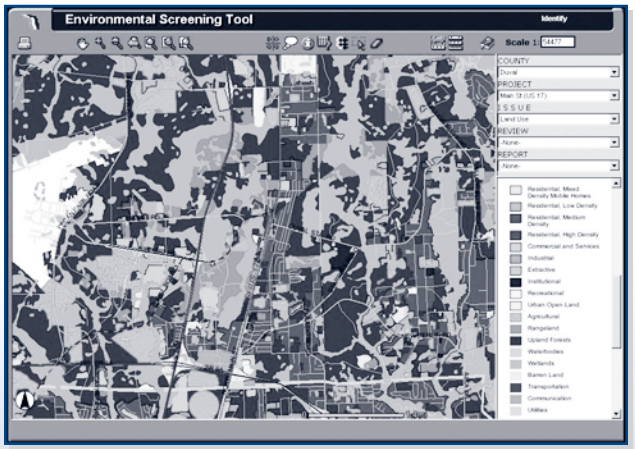
Successful Applications: States get results from GIS

The Florida Department of Transportation's (DOT) Efficient Transportation Decision Making (ETDM) process links land use, transportation, and environmental resource planning initiatives by actively involving agencies and the community. ETDM identifies critical issues early in the planning phase to reduce conflicts among permitting agencies. The process uses state-of-the-art technologies, including GIS and Web-based communication tools, to allow team members to communicate more effectively. Technologies such as these will improve decisionmaking and may significantly reduce the time, effort, and cost required to implement transportation plans while helping to protect human and natural environments.

The Indiana DOT, in association with the Indiana Geological Survey, compiled a GIS application for long-range planning and to help develop projects under the National Environmental Policy Act. The application includes more than 170 different geospatial data layers, ranging from environmental

resources to socioeconomic, historical, and geologic feature data. Data originally was selected from several State and Federal agencies, and was edited and formatted. This application was first used in southwestern Indiana to help complete a Tier 1 Environmental Impact Statement for the U.S. Interstate 69 project. The data coordination effort was so effective that a Statewide GIS expansion has been completed. The Indiana GIS application will streamline future project development and reduce staff workload and fiscal demands.

Washington State and Washington State DOT have become national leaders in developing innovative methods to share geographic data. One such method is the Environmental GIS Workbench, managed by the Washington State DOT's Environmental Information Program (EIP). The Environmental GIS Workbench is a custom-built application that provides access to a broad range of Statewide environmental and natural resource management data. The EIP supports the GIS application by coordinating with numerous Federal, State, and local agencies to ensure that datasets are updated continuously and remain accurate. The increased availability of information has reduced decision review time, while EIP-centralized system control maintains and improves data accuracy. The digitized data layers are available as ArcView™ readable files and may easily be downloaded, overlaid, and manipulated.



A screenshot of Florida DOT's Environmental Screening Tool, which allows viewers to see where proposed transportation projects will be located with respect to nearby land uses and environmentally sensitive areas

Benefits

- Encourages partnership/data sharing.
- Identifies potential problems early in the planning process.
- Focuses on key technical issues.
- Provides agencies and communities with access to quality data.
- Improves feedback with summary reports and maps.

Additional Resources

The Federal Highway Administration recently updated its National Highway Institute training course, "Applying Spatial Data Technologies to Transportation." To learn more about Florida's ETDM, visit www.dot.state.fl.us/emo. Additional information about Indiana's GIS application is available at http://igs.indiana.edu/arcims/index.html. For more information about Washington State's Environmental GIS Workbench, visit www.wsdot.wa.gov/environment/eao/envinfo/egwbhome.htm

For more information, contact:

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Interagency Funding Guidance for Environmental Streamlining

Problem: Streamlining environmental reviews demands agency resources

To implement environmental streamlining initiatives, Federal, State, and local transportation and resource agencies must coordinate their activities throughout the environmental review process. However, many of these agencies lack sufficient staff to expedite this process. To help overcome this obstacle, many State departments of transportation (DOT) are using interagency funding agreements to hire additional staff for resource agencies. Section 1309(e) of the Transportation Equity Act for the 21st Century (TEA-21) allows States to use Federal-aid project funds through interagency agreements (cost reimbursement) to provide additional resources to Federal and State agencies involved in environmental streamlining activities. However, establishing interagency agreements can be challenging and intimidating, so the Federal Highway Administration (FHWA) is helping facilitate this process.

Solution: Provide guidance to expedite interagency agreements

To expedite the development of interagency funding agreements, FHWA finalized its *Interagency Guidance: Transportation Funding for Federal Agency Coordination Associated with Environmental Streamlining Activities* in February 2002. FHWA developed the guidance with input from the Federal Transit Administration, the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS), the U.S. Army Corps of Engineers (USACE), the Advisory Council on Historic Preservation, and State DOTs. The guidance provides a common understanding among USDOT, State DOTs, local transit operators, and Federal resource agencies regarding funding options under TEA-21 to help Federal and State resource agencies streamline reviews of Federal-aid transportation projects. The guidance is intended to provide a common understanding between Federal and State departments of transportation (DOT), local transit operators, and Federal resource agencies regarding options for using funding under Title 23 and Section 1309(e) of TEA-21. These agencies may develop interagency agreements to support Federal resource agency coordination for streamlining the review of Federal-aid transportation projects.

The guidance includes:

- Instructions for developing interagency funding agreements, including key elements to include.
- A recommended template for interagency funding agreements.
- Examples of current interagency funding agreements.
- A summary of lessons learned and best practices used by States to expedite reviews.
- Descriptions of eligible activities and other funding mechanisms.

Putting It in Perspective

Funding agreements should:

- Include job descriptions and performance measures to set expectations and ensure funded staff's involvement in the transportation process.
- Provide dispute resolution procedures for participating agencies.
- Establish agreements for at least 2–3 years to allow time to recruit and train qualified staff.
- Designate one State DOT staff member to administer funding agreements.
- Require States to work closely with resource agencies to interview and select candidates.
- Provide guidance for training new hires in the transportation project development and National Environmental Policy Act (NEPA) processes.
- Require frequent meetings between funded staff and resource agencies to discuss what is and is not working.

Successful Applications: Current State DOT funding agreements

State	Positions Funded	Purpose	Benefits
Maryland	3 positions since 2000 (EPA, FWS, USACE).	Assure resource agency involvement in planning and project development. Expedite permitting and project reviews.	Improved interagency communication and understanding of other agencies' missions.
North Carolina	22 positions since early 1990s (EPA, FWS, State agencies).	Expedite the project development process as the number of projects and complexity of environmental regulations continue to grow. Identify and resolve problems early. Help implement a NEPA/404 merger.	Improved interagency communication, program delivery, and project quality.
Pennsylvania	18 positions since 1993 (EPA, FWS, USACE, State agencies).	Expedite document review. Encourage early coordination.	Improved quality of the project development process by identifying sensitive areas and issues early. Improved coordination with metropolitan planning organizations and resource agencies (next step).
South Carolina	4 positions since 2001 (FWS, State agencies).	Provide staff for quick reviews (required by an accelerated State bonding program).	Reduced section 401 permit time by 30 percent. Reduced State Historic Preservation Office review time from 30 to 7 days.
Washington	32 liaisons since late 1990s (EPA, FWS, National Marine Fisheries Service, USACE, State agencies).	Provide adequate staff to participate in pilot projects and streamlining activities.	Allowed quick processing of backlogged reviews and permitting work. Develop performance measures and Memoranda of Agreement for positions (next step).

Benefits

- Interagency agreements help improve coordination among many agencies.
- Funded staff are dedicated to reviewing transportation projects and making permit decisions, and help reduce the time it takes to complete environmental reviews on specific projects.
- State DOTs develop quality transportation and environmental solutions efficiently and cost-effectively.

Additional Resources

Interagency Guidance: Transportation Funding for Federal Agency Coordination Associated with Environmental Streamlining Activities is available at **http://environment.fhwa.dot.gov/strmlng/igdocs/index.htm**.

For more information, contact:

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Intelligent Transportation Systems (ITS) SpecWizard

Problem: Effective intelligent transportation systems require consistent specification standards

Intelligent transportation systems (ITS) can be cutting-edge technologies that help improve roadway safety and enhance the Nation's mobility. ITS specifications that are not based on industry-consensus standards, however, can limit interoperability and interchangeability, ultimately affecting the system's expandability and interjurisdictional coordination. By specifying the functions and format of messages between devices and between systems, the National Transportation Communications for ITS Protocol (NTCIP) helps ensure that systems function efficiently.

Solution: SpecWizard™ helps write standards into ITS specifications

To help transportation agencies ensure ITS efficiency, the U.S. Department of Transportation's ITS Standards Program procured SpecWizard.

What is SpecWizard?
SpecWizard is a software tool that helps specification developers write specifications for NTCIP standards-based ITS equipment. NTCIP standards are open standards—ITS equipment based on these standards offer greater levels of interoperability and interchangeability than equipment not based on NTCIP standards. NTCIP standards safeguard transportation agencies from being locked into proprietary solutions.

How does it work?
SpecWizard analyzes a user's answers to a series of key questions about a specific ITS deployment (such as desired features for the device, maintenance plans and support, and other issues), and produces a text file that can be edited and incorporated into a specification for NTCIP-based equipment. SpecWizard currently addresses deployments for:

- Dynamic message signs (DMS).
- Environmental sensor stations.
- Signal controllers.

SpecWizard's capabilities may be expanded, depending on demand.

Successful Applications

SpecWizard is just now being used for DMS procurements. FHWA provides a DMS procurement workshop to public agencies that identify issues related to developing ITS specifications in general and DMS specifications specifically. The workshop also is available to private sector consultants that are currently under contract with a public sector agency, if they attend with the agency contact. The workshop teaches agencies how to use SpecWizard to develop the NTCIP section of a DMS specification. SpecWizard has been distributed through the DMS Application Workshop to participants in Florida, Idaho, Illinois, Louisiana, Montana, New Hampshire, North Dakota, Pennsylvania, South Dakota, Vermont, Virginia, and Wyoming, and an increasing number of locations have purchased SpecWizard directly.

Benefits

- Is an easy-to-use software program with a familiar interface.
- Features a bandwidth analysis tool, which combines specific communications system performance and polling desires with NTCIP requirements and alerts users to any expected performance problems.

Additional Resources

SpecWizard is available from the McTrans online catalogue at **www-mctrans.ce.ufl.edu** or can be ordered by phone at 1–800–226–1013. Free updates to SpecWizard will be available when the new version of the DMS standard is released in 2004.

Focused, short-term technical assistance is available to public agencies through the ITS Standards Program's field support team. Contact your FHWA Resource Center or FHWA Division Office.

For more information, contact:

Jason Hedley,
FHWA Office of Transportation Management
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E-mail: jason.hedley@fhwa.dot.gov

Paul Olson,
FHWA Resource Center, San Francisco, CA
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E-mail: paul.olson@fhwa.dot.gov

ITS SpecWizard CD-ROM with computer system requirements and installation instructions

FHWA-HRT-04-058
HRTS-03/01-04(1M)E

U.S. Department of Transportation
Federal Highway Administration

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Load and Resistance Factor Design and Rating of Structures

Problem: Transportation agencies seek a more uniform level of safety and reliability for highway structures

A 1987 Transportation Research Board study concluded that the American Association of State Highway and Transportation Officials' (AASHTO) *Standard Specifications for Highway Bridges* contained gaps and inconsistencies, and did not utilize the latest design philosophy and knowledge. In response, AASHTO adopted the *Load and Resistance Factor Design (LRFD) Specification* in 1994 and the *Load and Resistance Factor Rating (LRFR) Guide Specification* in 2002.

What is LRFD?
LRFD incorporates state-of-the-art analysis and design methodologies with load and resistance factors based on the known variability of applied loads and material properties. These load and resistance factors are calibrated from actual bridge statistics to ensure a uniform level of safety.

How does LRFD work?
Without LRFD, a bridge designer focuses on a design objective or limit state, which can lead to a similar probability of failure in each component. Bridges designed with the LRFD specifications should have more uniform safety levels, which should ensure superior serviceability and long-term maintainability.

Because of LRFD's impact on the safety, reliability, and serviceability of the Nation's bridge inventory, AASHTO, in concurrence with the Federal Highway Administration (FHWA), has set a transition deadline of October 1, 2007. After this date, States must design all new bridges according to the LRFD specifications.

Putting It in Perspective

- The National Bridge Inventory (NBI) contains more than 590,000 bridges.
- Forty percent of all NBI bridges are more than 40 years old.
- Design life when these bridges were constructed was often only 50 years.

Solution: Provide resources to help States implement LRFD

To facilitate and ensure that the States accomplish this transition by the 2007 deadline, FHWA has developed a strategic plan. The plan involves the following:

- Identify past, current, and future State LRFD implementation plans.
- Identify and deploy a showcase of successful State LRFD implementations.
- Develop an implementation plan and guidelines that States can use to identify and prioritize steps toward a successful LRFD implementation: make decisions, set priorities, determine actions, review performance on a regular basis, and make needed changes to the plan.
- Deploy planning assistance to provide hands-on implementation and transition planning that integrates States into the detailed implementation planning process.
- Develop comprehensive design examples.
- Deploy prompt technical LRFD training and assistance to States.

- Develop detailed, hands-on training courses.
- Compile a comprehensive list of LRFD resources (books, software, courses).
- Support LRFD research.

FHWA has a team of structural engineers who are available to meet with individual States and provide guidance in developing a State-specific LRFD implementation plan. In addition, the following products have been developed to assist States:

- Tips for successful LRFD implementation.
- A model State implementation plan (with roadmap items).
- Comprehensive LRFD resource list (training courses, design examples, books, and software).

FHWA is developing two comprehensive design examples (deck to foundation), and two topic-specific training courses. This training will be available through the National Highway Institute by the end of 2004. FHWA also has developed training workshops for bridge superstructures (steel and concrete), and will develop geotechnical training workshops, as well.

Successful Applications: Some States have completed LRFD implementation

Ten States already have fully implemented the LRFD specifications, with positive results. Another 23 States have partially implemented LRFD or have developed sample LRFD designs. Eleven States have worked with FHWA to develop implementation plans and begin the transition to LRFD. Many other States have expressed a strong interest in working with FHWA to develop an LRFD implementation plan to facilitate their transition to the LRFD specifications by 2007.

Benefits

- Uniform level of safety and reliability.
- State-of-the-art specifications that utilize the latest research and bridge knowledge.
- Superior serviceability and long-term maintainability.
- More robust structures with longer service lives and reduced need for major maintenance.

For more information, contact:

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FHWA-HRT-04-059
HRTS-03/01-04(1M)E

U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Pavement Smoothness Methodologies

Problem: Rough pavements contribute to inefficient roadways

Pavement smoothness is probably the single most important indicator of performance from the standpoint of the traveling public. National surveys of road users list smooth pavements as a top highway characteristic. Rough or uneven pavements adversely affect driver safety, fuel efficiency, ride quality, and vehicle wear-and-tear. Rough pavements also negatively impact pavement durability.

Putting It in Perspective

- In a 2002 Federal Highway Administration (FHWA) survey, road condition was cited as the public's number one criteria for satisfaction.
- A National Cooperative Highway Research Program analysis showed that improved smoothness extends pavement performance life by as much as 50 percent.

Solution: Improve pavement smoothness technologies

Because of the public's focus on smoothness, any improvements made in both the initial and long-term smoothness of a roadway should lead directly to greater customer satisfaction.

Why is pavement smoothness important?
The functionality and performance of smooth pavements is better than that of rough pavements. Furthermore, high levels of initial smoothness have been shown to have a significant effect on the future smoothness of pavements, and also have been linked to increases in pavement life.

Successful Applications: New products help improve the condition of the Nation's highways

American Association of State Highway and Transportation Officials (AASHTO) Provisional Standards

The *Provisional Standards for Pavement Smoothness*, adopted by AASHTO in June 2003, provide a standard set of specifications and protocols to assure owner agencies that test results from inertial profilers are both repeatable and reproducible.

The Provisional Standards include the following components:

- MP11-03 Profiler Equipment Specification.
- PP49-03 Profiler Certification Program.
- PP50-03 Smoothness Measurement Test Methods.
- PP51-03 Pavement Smoothness Specification.

Ongoing research will enhance these provisional standards to full standards within 7 years. Active research conducted under the FHWA research contract, "Smoothness Criteria for Concrete Pavements" will provide answers to questions concerning the appropriate specification limits, the value of enhanced smoothness, and methodologies for identifying localized roughness.

National Highway Institute (NHI) course on pavement smoothness measurement

A training course offered by NHI, "Factors Affecting Inertial Profile Measurements for Construction Quality Control" (NHI 131100) is an integral part of the PP49-03 Profiler Certification Program. This training course highlights the appropriate application of inertial profilers for construction quality control.

Pavement Profile Viewer and Analyzer (ProVAL) software

Advanced profile analysis capabilities, developed to support the Provisional Standards, currently are available as part of the ProVAL software. This software provides advanced profile analysis techniques such as power spectral density and cross correlation. ProVAL software is available at **www.roadprofile.com**.

Benefits

- Ensuring pavement smoothness during initial construction saves money and improves durability over the life of the pavement.
- Pavement smoothness enhances the safety and mobility of the Nation's highways.

Lightweight profiler

Additional Resources

After an agency has implemented an improved pavement smoothness specification based on inertial profilers, methods for achieving these specifications must be provided to contractors. Best practice guides for pavement smoothness for both asphalt and concrete pavements are available from the FHWA Office of Pavement Technology. These guides provide concise information about measuring, expressing, specifying, and achieving pavement smoothness.

For more information, contact:

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

QuickZone

Problem: Work zones contribute to traffic delays

According to a survey released by the Federal Highway Administration (FHWA), travelers view road repairs as a major contributor to traffic delays, and believe that improvements in traffic flow, pavement conditions, and work zones can enhance driver satisfaction significantly. Despite these findings, with the exception of a few high-visibility freeway construction and refurbishment projects, project planners typically do not consider the soft cost of traveler delay when making key decisions about project staging and duration.

The 1998 FHWA report, *Meeting the Customer's Needs for Mobility and Safety During Construction and Maintenance Operations*, highlighted this issue and recommended developing an easy-to-master analytical tool to quickly and flexibly estimate and quantify work zone delays in all four phases of the project development process (policy, planning, design, and operations). The result was a traffic delay estimation tool called QuickZone, which is designed for State and local traffic construction, operations, and construction planning contractors.

Putting It in Perspective

- Work zones account for nearly 24 percent of nonrecurring congestion, which translates to 482 million vehicle hours of delay per year.
- The four main causes of nonrecurring congestion are crashes, weather, work zones, and breakdowns.

Solution: Reducing work zone delays with QuickZone

What is QuickZone?
QuickZone is a traffic impact analysis tool that can be used to estimate work zone delays. For example, QuickZone allows road owners and contractors to compare the effects of doing highway work at night instead of during the day, or of diverting the traffic to different roads at various stages of construction. These effects can be estimated for periods as short as one day or for the entire life of the construction project. QuickZone provides an easy-to-use, easy-to-learn tool that takes advantage of software tools that are familiar to the target user base.

How does QuickZone work?
QuickZone is an open source, Microsoft®-based application suitable for urban and interurban corridor analysis. QuickZone can:

- Quantify corridor delay resulting from capacity decreases in work zones.
- Identify delay impacts of alternative project phasing plans.
- Support tradeoff analyses between construction costs and delay costs.
- Examine the impacts of construction staging by location along mainline, time-of-day (peak vs. off-peak), and season (summer vs. winter).
- Assess travel demand measures and other delay mitigation strategies.
- Help establish work completion incentives.

QuickZone runs on a personal computer, furnishing the information in spreadsheet format. The system prompts users for the data needed to perform the necessary calculations. QuickZone can compare the traffic impacts for work zone mitigation strategies and estimate the costs to motorists in terms of delays and potential backups associated with different strategies or scenarios.

To operate effectively, QuickZone requires:

- Network data—Node data (X-Y coordinates), link data (capacity, length).
- Demand data—Average daily travel, daily and seasonal distributions.

Successful Applications: Decreasing delay in Pennsylvania

In summer 2002, motorists on U.S. Interstate 80 (I-80) in Clarion County, PA experienced significant delays and frustrations caused by traffic backups in highway work zones, and the Pennsylvania Department of Transportation (PENNDOT) received complaints. In response, before beginning a resurfacing project on I-80 in Butler and Clarion Counties, PENNDOT's District 10 turned to QuickZone.

QuickZone helped engineers model different work zone configurations before implementing them on the highway. Applying the software to the I-80 project, PENNDOT engineers were able to select work zone configurations and construction schedules that met project needs while minimizing impacts to the traveling public. Based on the reduced number of complaints and the length of time motorists experienced delays in the work zone, PENNDOT believes the effort was a success. "We are very pleased with the results of QuickZone modeling," said Richard H. Hogg, Professional Engineer, District 10 executive. "Based on what we saw occur on the interstate last year compared to this year, the improvements for our customers, the traveling public, are significant."

Benefits

- Graphic and tabular outputs.
- Low software and hardware operating requirements.
- User-friendly.
- Effective at reducing work zone delays.

Additional Resources

To purchase QuickZone, visit **www-mctrans.ce.ufl.edu** or **www.kutc.ku.edu/pctrans**. The cost is $195.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Red Light Cameras

Problem: Intersection crashes account for more than 40 percent of all crashes

Intersection safety is a serious problem in the United States, and it is one of the Federal Highway Administration's (FHWA) top priorities.

The National Highway Traffic Safety Administration reports that about 6.4 million crashes occurred on the Nation's roadways in 2000. Approximately 40 percent of all crashes are intersection-related. Red-light-running (RLR) causes more than 180,000 crashes every year, resulting in approximately 1,000 deaths and 90,000 injuries a year. The number of fatal motor vehicle crashes at traffic signals is rising faster than any other type of fatal crash nationwide.

When does RLR occur?
RLR occurs when a driver enters an intersection after the traffic signal has turned red. The traditional way of enforcing this violation is to station a patrol vehicle near an intersection. This method is dangerous for the officer, expensive to localities, and drains valuable police resources. Red light cameras can supplement police efforts by being where officers cannot be all the time.

Putting It in Perspective

- Motorists are more likely to be injured in crashes involving RLR than in other types of crashes. Occupant injuries occurred in 45 percent of the RLR crashes, compared to 30 percent for other crash types.
- According to a survey conducted by U. S. Department of Transportation and the American Trauma Society, 63 percent of Americans witness a RLR incident more than once a week. One in three Americans knows someone who has been injured or killed because of a red light runner.

Solution: Red light camera technology can make intersections safer

What are red light cameras?
Red light cameras detect a motor vehicle that passes over sensors in the pavement after a traffic signal has turned red. The sensors are connected to computers in high-speed cameras, which take two photographs of the violation. The first photo is taken of the front of the vehicle when it enters the intersection, and the second is taken when the vehicle is in the intersection.

Law enforcement officials review the photograph, and in many localities, a citation is mailed to the registered owner of the vehicle. The owner can challenge the citation if he or she was not the driver at the time of the violation.

Successful Applications: Research demonstrates crash reductions

Based on a survey conducted as a part of a National Cooperative Highway Research Program synthesis project, a majority of jurisdictions reported downward trends in RLR-related violations and crashes because of red light cameras.

- In Fairfax, VA, violations were reduced by 41 percent after 1 year of camera enforcement.
- San Francisco, CA and Los Angeles, CA realized a 68- and 92-percent reduction in violations, respectively.
- In Charlotte, NC, RLR violations were reduced by more than 70 percent during the first year of operation.

According to FHWA's *Guidance for Using Red Light Cameras*, the following critical elements should be considered while installing red light camera systems:

- Conduct an engineering study before considering camera installation.
- Evaluate effective engineering and education alternatives before considering photo-enforcement.
- Make sure the red light camera program is engineered and installed properly.
- Measure, document, and make safety results available.
- Ensure complete oversight and supervision by public agencies.
- Avoid compensating vendors based on the number of citations.
- Include an ongoing photo-enforcement public education program.

Benefits

Automated enforcement systems can be effective and reliable tools to help reduce the number of RLR violations and associated crashes.

Additional Resources

FHWA has published a comprehensive publication, *Guidance for Using Red Light Cameras*. This document provides information to State and local agencies on how to initiate and operate an appropriate red light camera program. Call 202–366–5915 to order Publications No. FHWA-SA-03-018, or download this guide from the Web at **http://safety.fhwa.dot.gov/drlcguide/index.htm**.

Visit **http://safety.fhwa.dot.gov/srlr.htm** for more information on how to prevent RLR.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Roundabouts

Problem: Intersection crashes account for more than 40 percent of all crashes

Intersection safety is a serious problem in the United States, and addressing this problem is one of the Federal Highway Administration's (FHWA) top priorities.

In 2001, there were nearly 3 million intersection-related crashes, accounting for more than 40 percent of all crashes in the United States. This same year, intersection fatalities rose to 8,876, or 21 percent of all traffic fatalities. In addition, approximately 50 percent, or 1.5 million, of all injury crashes occurred at intersections. Each year, side-impact crashes cause more than one-third of all vehicle occupant deaths. This type of collision occurs most frequently at intersections.

Why are there so many intersection crashes?
An intersection is, at its core, a planned point of conflict in the roadway system. With different crossing and entering movements by both drivers and pedestrians, an intersection is one of the most complex traffic situations that motorists encounter. Add the element of speeding motorists who disregard traffic controls, and the dangers are compounded.

Who is most likely to be affected?
Senior drivers and pedestrians are particularly vulnerable at intersections. Senior drivers (ages 65 years and older) are more likely than younger drivers to cause a fatal crash at an intersection. These drivers also are more likely to receive traffic citations for failing to yield, turning improperly, and running stop signs and red lights.

Putting It in Perspective

In 2001:

- One intersection-related fatality every hour.
- One intersection-related injury crash every 30 seconds.
- Financial loss of $90 billion from intersection crashes.

Solution: Roundabouts are a proven, international safety solution that prevent and reduce the severity of intersection crashes

Over the past 25 years, U.S. intersection designs and traffic engineering measures have improved, but the annual number of intersection fatalities has not changed significantly. To reduce crashes and improve intersection safety, FHWA recommends the use of roundabouts, where appropriate. Roundabouts must be designed to meet the needs of all road users—drivers, pedestrians, pedestrians with disabilities, and bicyclists. When designing roundabouts, special considerations must be given to the needs of pedestrians with visual disabilities who are unable to judge adequate gaps in traffic at roundabouts. Proper site selection and pedestrian channelization are essential to making roundabouts accessible to all users.

What is a roundabout and how does its design improve intersection safety?
A roundabout is a circular intersection that is designed to meet the needs of all road users—drivers, pedestrians, pedestrians with disabilities, and bicyclists.

A roundabout eliminates some of the conflict traffic, such as left turns, that cause crashes at traditional intersections. Because roundabout traffic enters or exits only through right turns, collisions that do occur typically are less severe than those at conventional intersections. A roundabout also is safer than a traffic circle or a rotary, both of which are larger and operate under different traffic rules.

The three safety design features of a roundabout are yield control of entering traffic; channelized approaches; and geometric entry curvature. These three features are key to the success of a roundabout, because they effectively decrease driving speed (typically to 48 kilometers per hour (30 miles per hour) or less). Unlike a traffic circle or a rotary, a roundabout's incoming traffic yields to the circulating traffic. This creates a safer driving environment than that of traditional intersections.

Successful Applications: Roundabouts demonstrate success in reducing crashes

Research indicates that well-designed roundabouts can be safer and more efficient than conventional intersections. A December 2002 report by the Maryland Highway Administration indicates that 15 single-lane roundabouts have greatly improved intersection safety in that State. The analysis shows a 100 percent decrease in the fatal crash rate; a 60 percent decrease in the total crash rate; an 82 percent reduction in the injury crash rate; and a 27 percent reduction in the property damage-only accident rate. This report is available for download at http://safety.fhwa.dot.gov.

Benefits

- Crashes are less severe than other intersection crashes.
- Safer than traditional intersections.
- Cost-effective way to improve intersection safety.

Additional Resources

FHWA has published a comprehensive guide called *Roundabouts: An Informational Guide*. The information supplied in this document is based on established international and U.S. practices and is supplemented by recent research. Call 202–366–5915 to order Publication No. FHWA-RD-00-067, or download this guide from the Web at www.tfhrc.gov/safety/00068.htm.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Rumble Strips

Problem: Roadway departures account for more than half of all roadway fatalities

Roadway departure fatalities, which include run-off-the-road (ROR) and head-on fatalities, are a serious problem in the United States. In 2001, there were 23,205 roadway departure fatalities, accounting for 55 percent of all roadway fatalities in the United States. That same year:

- 16,256 people died in ROR crashes (38.5 percent of all roadway fatalities).
- Head-on crashes represented 15.7 percent (6,627 total) of all crashes.
- There were 740,000 roadway departure injury crashes, accounting for 35 percent of all injury crashes.

Why are there so many roadway departure crashes?
There are many contributing factors. Driver fatigue and drowsiness can contribute to ROR crashes; a drowsy driver can be as dangerous as a drunk driver. In other cases, drivers are inattentive, careless, or distracted, and drift out of the lane and off the road. Visibility is also an issue. The majority of accidents happen at night. Moreover, 70 percent of ROR fatalities occur on rural highways, about 90 percent occur on two-lane roads, and rural highways usually are not as well lit as urban roadways. Inclement weather such as fog, snow, smoke, or dust storms also can decrease pavement marking visibility, and in these conditions, drivers may drive off the road accidentally.

Putting It in Perspective

- Forty percent (2,600,000) of all crashes were roadway departure crashes.
- On average, one roadway departure fatality crash occurred every 26 minutes.
- An average of one roadway departure injury crash occurred every 43 seconds.
- The estimated annual cost of roadway departure crashes is $100 billion.

Solution: Rumble strips are proven, cost-effective way to help prevent roadway departure crashes

Shoulder rumble strips have proven to be very effective for warning drivers that they are about to drive off the road. Many studies also show very high benefit-to-cost (B/C) ratios for shoulder rumble strips, making them among the most cost-effective safety features available. For example, Nevada found that with a B/C ratio ranging from more than 30:1 to more than 60:1, rumble strips are more cost effective than many other safety features, including guardrails, culvert-end treatments, and slope flattening. And a Maine Department of Transportation (DOT) survey of 50 State DOTs identified a B/C ratio of 50:1 for milled rumble strips on rural interstates nationwide.

What are rumble strips and how do they improve roadway safety?
Rumble strips are raised or grooved patterns on the roadway shoulder that provide both an audible warning (rumbling sound) and a physical vibration to alert drivers that they are leaving the driving lane. In addition to warning inattentive drivers, rumble strips help drivers stay on the road during inclement weather when visibility is poor. Some States paint stripes over the rumble strips to make them visible; these are called rumble stripes.

There are three types of rumble strips. The most common type of strip is the continuous shoulder rumble strip. These are located on the road shoulder to prevent roadway departure crashes on expressways, interstates, parkways, and two-lane rural roadways. Centerline rumble strips are used on some two-lane rural highways to prevent head-on collisions. Transverse rumble strips are installed on approaches to intersections, toll plazas, horizontal curves, and work zones.

Successful Applications: State studies show success in reducing ROR crashes

After Delaware DOT installed centerline rumble strips on U.S. Route 301—a two-lane, undivided rural highway with a high fatality rate—the head-on collision rate decreased 90 percent, and fatalities decreased to zero. These dramatic safety improvements were achieved despite a 30 percent increase in traffic.

A New York study showed a significant change in the reduction of ROR crashes, injuries, and fatalities after rumble strips were installed on the New York Thruway. ROR crashes were reduced 88 percent, from a high of 588 crashes in 1993 to 74 in 1997. Total injuries were reduced 87 percent, from a 1992 high of 407 to 54 in 1997. Fatalities were reduced 95 percent, from 17 in 1991 and 1992 to 1 fatality in 1997.

Virginia DOT won the 2001 National Highway Safety Award for its experiment with continuous shoulder rumble strips (CSRS) on the State's 1,476-kilometer (917-mile) interstate highway system from 1997–2000. During this project, ROR crashes were reduced by 51.5 percent, saving an estimated 52 lives. It is estimated that CSRS technology has prevented 1,085 injuries and 1,150 ROR crashes, with a total cost savings of $31.2 million.

Benefits

- Reduce ROR crashes caused by driver inattention, driver error, visibility, and fatigue.
- Are inexpensive to install.
- Cause no noticeable pavement degradation.
- Require little or no maintenance.
- Can be installed on new or existing pavements (milled rumble strips).

Additional Resources

Visit the Federal Highway Administration (FHWA) Rumble Strip Web site at **http://safety.fhwa.dot.gov/programs/rumble.htm**, and view our Technical Advisory, *Roadway Shoulder Rumble Strips*, at **www.fhwa.dot.gov/legsregs/directives/techadvs/t504035.htm**.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Safe Speeds in Work Zones

Problem: Speeding in work zones causes injuries and fatalities

In 2001, there were 106,000 work zone crashes, accounting for 1.7 percent of all roadway crashes. These crashes resulted in 1,079 work zone fatalities, or an average of 3 deaths every day. In that same year, 47,000 people were injured in work zone crashes—an average of one injury every 11 minutes. When drivers speed through work zones, crash risks increase.

Why do drivers disregard speed limit signs in work zones?
Studies show that motorists do reduce driving speeds in work zones—even in work zones with no speed limit reductions—but not to the levels posted. As a source of traffic delays, work zones can cause driver frustration. In addition, sometimes the signs posted in work zones do not accurately reflect the current driving conditions, and drivers learn to disregard them.

Drivers disregard static signs that don't reflect current driving speeds

Many factors contribute to the lack of credibility for speed limit signing; the most critical factor is that, because of changes in volume, lighting, work activity, weather, and other conditions, the appropriate safe speed changes throughout the day. This is particularly true in highway work zones.

For example, a reduced speed limit when there is no roadwork activity encourages drivers to disregard the speed restriction when workers are present. If the speed signs are not current, they are not credible and will be ignored.

Putting It in Perspective

In 2001, on average:

- Three people a day died as a result of work zone crashes.
- One work zone crash occurred every 5 minutes.
- Every day, 130 people were injured in work zones.

Solution: Work zone speed display technologies help manage safe speeds

What are work zone speed displays?
Work zone speed displays are intelligent transportation system technologies that give drivers current and accurate information about safe driving speeds. There are several types of work zone speed displays.

Variable Speed Limit (VSL)
The VSL systems provide real-time information on appropriate speeds for current conditions and warn drivers of coming road conditions. These systems consist of multiple roadside monitoring and display trailers, each independently powered and controlled. Each speed trailer uses detectors to measure traffic speed and roadway conditions. A microcontroller processes this information along with other inputs, such as nature and duration of roadwork activity, to determine the appropriate speed limit, which is displayed on a trailer-mounted variable speed limit sign. The posted speeds can vary throughout the work zone.

VSL trailer displays safe speed based on road work and traffic conditions

Speed Feedback

A second type of work zone speed display is the Speed Feedback display, which informs approaching drivers of their current speed and encourages them to slow down if they are traveling above the speed limit. This is a portable display that can be moved to areas where speed is a problem. A maximum display speed is usually set to discourage drivers from competing to post higher speeds on the display.

How do these displays help reduce driving speeds?

Credible speed limits combined with timely advance warnings are essential for improving mobility and safety through work zones. VSL systems overcome many of the problems of static speed limit signs. Because these systems provide real-time information on appropriate speeds for current roadwork conditions, drivers will trust and use VSL information. The Speed Feedback display is effective because it gives drivers immediate feedback on their individual driving speeds. This feedback alerts drivers to specific driving behaviors.

Speed Feedback display encourages speeding drivers to comply to posted limit

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HRTS-03/01-04(1M)E

Successful Applications: Speed displays reduce vehicle speeds in several States

State highway agencies in Iowa, Kansas, Nebraska, and Wisconsin deployed speed feedback signs in rural high-speed work zones as part of the Midwest Smart Work Zone Deployment Initiative. The feedback signs reduced speeds by about 8 kilometers (5 miles) per hour; each 1.6 kilometer (1 mile) per hour reduction in speed may reduce injury crashes by 5 percent. Similar speed reductions have been observed by the Texas Department of Transportation (DOT) in rural, short-term work zones, and by the New Mexico State Highway and Transportation Department in urban work zones.

The Michigan DOT deployed a VSL system in one direction within an 29-kilometer (18-mile) work zone on U.S. Interstate 96 during the 2002 construction season. Travel time was reduced through the work zone because higher speeds were posted when appropriate. With the VSL in operation, driving speeds were slower through the work zone median crossover than when a static "50 miles per hour" limit was displayed, suggesting that variable speed limits were more credible. Ten crashes occurred in the direction with static speed limits, compared to only two crashes in the VSL direction.

Benefits

Work zone speed displays:

- Are portable and can be moved to new areas where speed management is needed.
- Provide current and credible information to drivers.
- Require minimal maintenance.

Additional Resources

FHWA requires that VSL systems and Speed Feedback displays conform to the national standards described in the Manual on *Uniform Traffic Control Devices* (MUTCD). For more information, visit the FHWA MUTCD Web site at **http://mutcd.fhwa.dot.gov**.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Transportation, Economic, and Land Use (TELUS) System

Problem: Metropolitan planning organizations struggle with expanded role in transportation decisionmaking

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 changed the future of transportation planning. Local elected officials within metropolitan planning organizations (MPO) were empowered with major roles in shaping the transportation networks in their communities. This expanded role in transportation decisionmaking, however, brought new responsibilities. Citizens, elected and appointed officials, and other stakeholder groups now were approaching MPOs to advocate projects, ascertain the status of projects, and lobby for project priorities. As a result, MPOs needed to reinvent their decisionmaking processes, expand their databases, and create more responsive public outreach programs.

Putting It in Perspective

As Edward Weiner wrote in *Urban Transportation Planning in the United States*:

- "Each metropolitan area had to prepare a long-range plan."
- "A reasonable opportunity for public comment was required before the long-range plan was approved."
- "A Transportation Improvement Program (TIP) was required...The TIP had to include a priority list of projects and a financial plan consistent with funding that could reasonably be expected to be available."

(from November/December 2002 *Public Roads*)

Solution: Design software to help MPOs manage multifaceted transportation planning process

To help MPOs and State departments of transportation (DOT) successfully meet these new challenges, TELUS was developed.

What is TELUS?
TELUS is a fully integrated information-management and decision-support system software that helps MPOs and State DOTs prepare annual TIPs and to carry out other responsibilities under the ISTEA reauthorization bill, the Transportation Equity Act for the 21st Century (TEA-21).

Information Management Features
- User customization.
- System security.
- Project scheduling.
- Project querying.
- Geographic information systems interface.
- Preformatted reports.
- Project revision and funding tracking.

Decision Support Features
- Project scoring.
- Project interrelationships.
- Planning analysis.
- Economic impacts (input-output model).
- Land-use model.

Successful Applications: Recent TELUS developments

Desktop TELUS 3.0 was released in May 2003; more than 50 MPOs have installed it and are using the system. In addition, several State DOTs are considering the system for potential use. New features include an input-output model, which allows users to estimate and display the associated job, income, and fiscal impacts of selected projects. Impacts are displayed with sector specificity, across the TIP's 5-year planning horizon, and against a background of projected overall jobs, incomes, and tax revenues.

Web TELUS 1.0, an Internet-enabled system, also has been released. This system parallels the desktop system but includes the advantages of a Web-based environment. The system is developed completely in Java™ and can be customized to meet an agency's requirements. Web TELUS 1.0 connects to existing data sources at the State DOT or MPO. It reduces data conversion when sharing information between State DOTs and MPOs, helps keep information current, facilitates standardization between MPOs, automates report generation (TIP and State TIP), and provides a user-friendly interface. By centralizing the location of the TELUS infrastructure at the State level, the maintenance costs for the MPO are reduced. The Web-based system has extensive security features, which act like firewalls to protect data, and it authenticates users and controls access based on the role of the user.

Benefits

- Provides free-of-charge, state-of-the-art TIP management software and technical assistance for MPOs and State DOTs.
- Customizes features for each user.
- Simplifies data management and reduces costs.

Additional Resources

Visit the Web TELUS 1.0 demonstration site at **www.telus-national.org** to learn more about the software.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Accelerated Construction

Problem: An aging system faces increasing traffic demand

Highway construction has intensified in recent years to address two challenges. First, the Nation's highway infrastructure is aging, because much of it was built during the 1950s and 1960s and needs to be rehabilitated or replaced. Second, although highway capacity has remained virtually unchanged during the past several decades, traffic demand has increased tremendously, causing high levels of congestion. Large construction projects to improve outdated roads and bridges compound traffic problems during extensive construction periods. Today's motorists demand high quality roads, but they want them put in place as quickly as possible; they will not settle for a "business as usual" approach.

Putting It in Perspective

Increasing demand (1980–2000):

- Vehicle miles of travel increased by 80 percent.
- Licensed drivers increased by 31 percent.
- Lane miles increased by only 3.8 percent.

An aging system:

- Forty percent of all bridges are more than 40 years old.
- When these bridges were constructed, design life was often only 50 years.
- Most pavement designs have a 20-year life expectancy.

Solution: Accelerated Construction Technology Transfer (ACTT) effectively reduces construction time while enhancing quality and safety on highways

ACTT aims to reduce construction time dramatically, saving money and improving safety and quality by minimizing the delays and hazards associated with work zones.

What is ACTT?
ACTT is a strategic process that uses various innovative techniques, strategies, and technologies to minimize actual construction time, while enhancing quality and safety on today's large, complex multiphase projects. Sponsored by the American Association of State Highway and Transportation Officials' (AASHTO) Technology Implementation Group (TIG) and the Federal Highway Administration (FHWA), the ACTT process begins with a 2-day workshop in which a multidisciplinary team of 20–30 national transportation experts works with an equal number of their local counterparts to evaluate all aspects of a project and develop recommendations for reducing construction time and enhancing safety and quality.

Key to the success is a team of experts working together in a coordinated, strategic approach to ensure that the project is completed better, faster, and safer. ACTT skill sets include:

- Right-of-way/utilities/railroad.
- Traffic engineering/safety/intelligent transportation systems.
- Structures.
- Innovative financing and contracting.
- Worker health and safety.

- Geotechnical/materials/accelerated testing.
- Long-life pavements/maintenance.
- Construction (techniques, automation, constructability).
- Environment/contest sensitive design.
- Roadway design/geometries.
- Public relations.

Benefits

- Reduces construction time.
- Mitigates congestion.
- Improves safety and quality.

Successful Applications: ACTT workshops and Project Pegasus

Transportation Research Board Task Force A5T60 was formed in 1999 to promote accelerated construction in the highway infrastructure. In 2002, the task force completed two ACTT pilot workshops in Indiana and Pennsylvania. AASHTO-TIG and FHWA are continuing the effort, and workshops in Texas, Louisiana, and California were conducted in 2003. Three to five annual workshops are planned for 2004 and 2005. Interest among State highway agencies has been very high, and six workshops already are scheduled for 2004.

In September 2003, the Texas Department of Transportation hosted an ACTT workshop on how to accelerate Project Pegasus, an initiative aimed at redesigning and improving the two major U.S. interstate freeways that serve downtown Dallas, TX—I-30 and I-35 East. The heavily congested freeways have outdated layouts. In many locations, ramps lack adequate acceleration or deceleration lengths, interchanges and ramps are too close together, and bridges have limited vertical and horizontal clearances, among other problems. The project requires weaving construction around railroad tracks, major employment sites, four city parks, and the Dealey Plaza historic district.

Workshop recommendations for accelerating the project included using design-build contracting; coordinating with utility companies early in the project planning process; using long-life pavements with a 50-year design lifespan; improving general materials specifications; establishing a dedicated incident management system at the project site; and introducing various traffic flow strategies. The goal of the accelerated construction plan is to complete the $760 million project in 4 years—3 years earlier than the original estimate.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Air Void Analyzer

Problem: Freeze-thaw cycles cause premature concrete deterioration

Premature deterioration of cement-based concrete structures puts a tremendous financial burden on many transportation agencies. Moreover, badly deteriorated concrete in pavements, bridges, and other highway structures adversely affects economic productivity by increasing the number of work zones while indirectly placing motorists at risk.

What causes concrete deterioration?
In much of the United States, concrete is deteriorating as a result of repeated freezing and thawing. Damage often is exacerbated by multiple applications of deicing salts, which accelerate cracking, deterioration, and surface scaling. Concrete life can be increased by improving its ability to endure repeated freeze-thaw cycles over its expected life cycle.

How do air voids affect the freeze-thaw resistance of concrete?
Closely spaced air voids in concrete are commonly singled out as the primary factor in improving the freeze-thaw resistance of concrete. Researchers believe that as water expands during freezing, the pressure the water develops increases in relation to the distance it must travel to reach the nearest air void. Consequently, the more closely air voids in concrete are spaced, the less likely it is that the pressure of freezing water will damage the concrete.

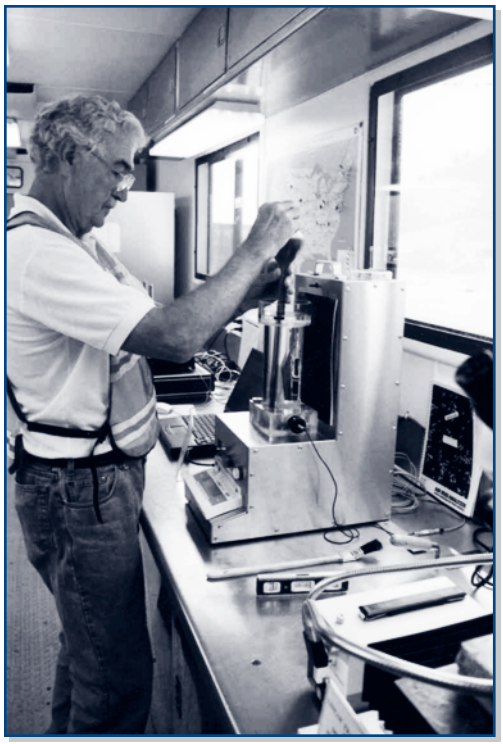
Putting It in Perspective

- Freeze-thaw issues are not confined to northern States.
- Even temperate States such as Texas and California have regions where pavement freezing occurs.
- Freeze-thaw damage may not become apparent until 10 or 15 years after construction.
- Current quality control (QC) state-of-practice (pressure meter) cannot characterize air void spacing.

Solution: Air void analyzer allows real-time testing of fresh concrete

The air void analyzer (AVA) offers an efficient, real-time method for assessing the distribution of air voids in fresh concrete. The device can characterize the air void distribution in less than 30 minutes. With this information, adjustments can be made in the concrete batching process to ensure that air voids are spaced properly.

How does the AVA work?
The AVA uses a small mortar sample (20 milliliters (0.68 fluid ounces)) extracted from the surface of fresh concrete using a vibrating cage and a syringe. The extracted mortar is injected into an assembly containing liquids with carefully controlled viscocities. As the mortar is injected, the air bubbles are released and rise through the liquids toward a boyancy recorder at the top of the assembly. The rate of rise of the bubbles is a function of their size. A data collection system tracks the change in buoyancy over time, and software determines the size distribution of the bubbles. From this data, the total air content, spacing factor, and specific surface are calculated.



Extracting an AVA sample

Successful Applications: AVA use prevents premature concrete deterioration

The Kansas Department of Transportation (DOT) began using the AVA in 2001 because of premature joint deterioration in 10-year-old concrete pavements. Sealing a deteriorated joint costs $3.25 per meter ($1 per foot), and additional sealing was anticipated over the remaining life of the pavement. In 2002, the Kansas DOT developed a concrete specification based on the AVA. It now uses the AVA for concrete mix qualification, with job site acceptance based on total air content. Cost savings from reduced repairs are estimated at $1.1 million for 2001–2002 projects.

Since 1999, the Federal Highway Administration (FHWA) has used AVA technology on projects in nine States. The variety of projects included pavements, precast sheet pile, foundation elements, and bridge decks. Roughly half of the concrete samples tested (using both the AVA and hardened air-content tests) had air void spacing factors outside the generally accepted limits for durable concrete, even though air content specifications (using conventional QC tests) were met. Results were based on 36 concrete samples collected on these 9 projects. These results highlight the importance of implementing the AVA to prevent appreciable quantities of concrete from being placed with inadequate frost resistance.

Benefits

- Provides timely results for onsite adjustments.
- Measures air void characteristics, not just volume.
- Allows for rapid in-situ QC and quality assurance testing.
- Can be used as a risk minimization tool.

Additional Resources

More information on the AVA, including case studies on States using the technology, is available at **www.aashtotig.org/focus_technologies/ava/**.

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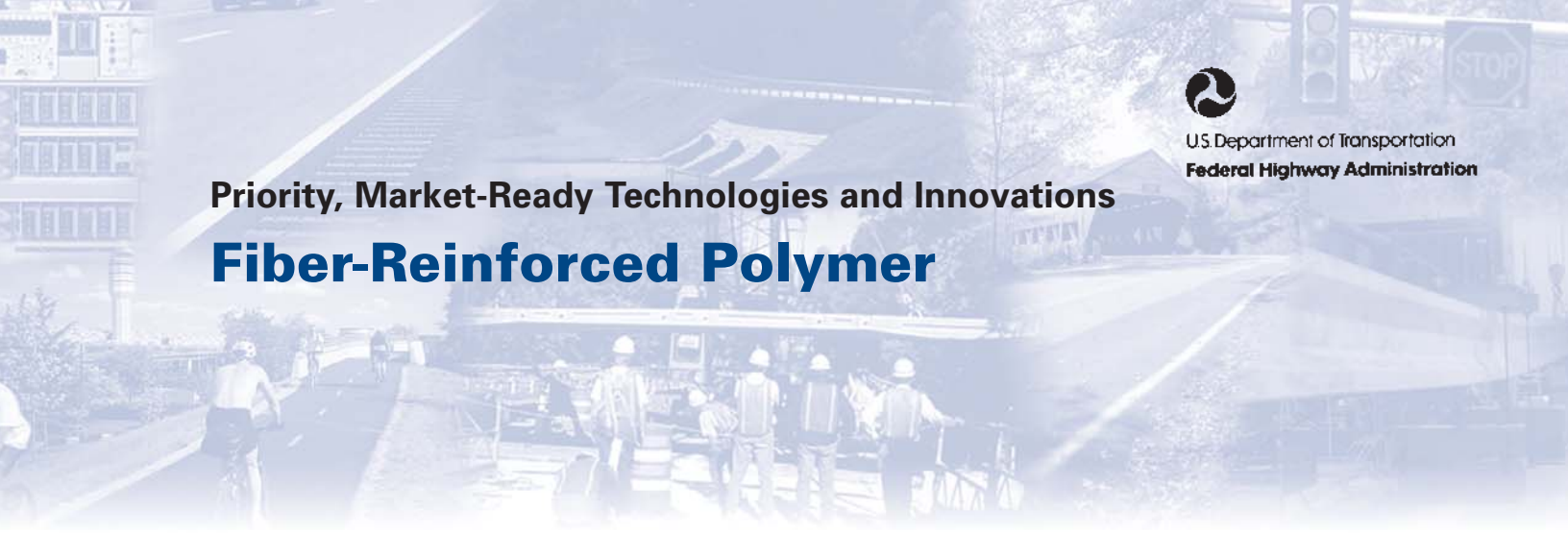

U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Fiber-Reinforced Polymer

Problem: Improperly maintained aluminum overhead sign structures create hazards

Overhead sign structures perform a valuable service to the traveling public. They support the signs that make travel safer by informing the driver well before any action is required. If these structures are not properly maintained, however, they can collapse onto the roadway below and create serious driving hazards.

How can collapse of sign structures be prevented?
The best insurance for preventing collapse of overhead sign structures is a comprehensive inspection program. When the New York State Department of Transportation (DOT) launched a sign inspection program in 2000, it found that 10 percent of the State's overhead sign structures were damaged. The most common problem was joint cracking between the internal trussing and the main chords of the sign structure, with some joints totally severed.

What causes cracks in sign structures?
The cause of cracks is difficult to determine and may stem from several factors. Lack of inspection during fabrication can yield poor-quality joint welds. Insufficient construction supervision may result in internal stresses in an overhead sign structure before the sign is attached. The greatest contributor may be that fatigue design was not a code requirement when many trusses were designed in the 1960s.

Putting It in Perspective

A 2002 survey of sign inspection practices at State transportation agencies found the following:

- In several instances, structures have failed and fallen into traffic below.
- Cantilever sign supports have the most problems, according to 54 percent of respondents.
- Problems cited most frequently were weld defects in sign and pole construction and general fatigue cracking.

Solution: Fiber-reinforced polymers repair overhead sign structures quickly and economically

Fiber-reinforced polymer (FRP) composite materials have the potential to revolutionize the repair of sign structures with cracked secondary support members. The Federal Highway Administration (FHWA) has researched the use of FRP for more than 20 years, and FRP has been used on a variety of bridges and other highway structures.

Using FRPs to repair cracked overhead sign structures represents one of the latest applications of these strong and durable materials in maintaining the Nation's aging highway infrastructure. FRPs can provide structural integrity to overhead sign supports and prevent them from failing.

How is FRP used to repair overhead sign structures?
The FRP repair method is relatively quick and economical. It is accomplished by cleaning the damaged area of the sign support thoroughly and wrapping FRP around it. Repairs can be done in place, with only the lanes below the repair area blocked off. A typical repair takes 3 workers 3 hours to complete, at an estimated cost of $3,000 per joint.

Successful Applications: Research shows FRP repairs as strong as welded joints

The New York State and Utah DOTs collaborated on a research program to study the feasibility of using FRP to repair overhead sign structures. Samples of cracked joints were salvaged from overhead sign structures that had been taken out of service. The samples were wrapped with FRP and sent to the University of Utah for tensile strength tests. Results showed that the repaired joints were as strong as if they had been fully welded. A second round of testing is being conducted to determine the effectiveness of FRP in resisting fatigue loads.

As a result of the research, the New York State DOT has developed a specification for using FRP in overhead sign repair. The specification covers restoration of the tensile capacity of secondary sign structural members, such as internal truss diagonals, and not main members, such as longitudinal truss chords. The specification has been approved for a 5-year lifespan with annual inspections of the repair.

Benefits

- Costs less than full structural support replacement.
- Allows repairs to be done quickly.
- Causes less traffic disruption because only lanes beneath repair need to be blocked off.

Additional Resources

Additional information about FRP is available at www.aashtotig.org/focus_technologies/frp/.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Global Positioning System (GPS) Surveying

Problem: Surveying land areas for highway infrastructures is time- and labor-intensive

There are considerable costs associated with conventional surveying technology. Methods are time-consuming and often require multiple trips to the same site to gather data and to ensure the collected data is accurate. In addition, workers must be trained to operate conventional surveying equipment properly. Weather also can delay data collection and highway surveys; crews are not always able to work under certain weather conditions, such as snow, rain, or extreme temperatures.

The Federal Highway Administration (FHWA) recognizes the importance of increasing survey accuracy while reducing labor costs and improving efficiency—addressing this problem is one of the Agency's top priorities.

Putting It in Perspective

- It takes many days to survey small sections of road using traditional techniques.
- Complete road inventories may take years.

Solution: GPS increases survey accuracy, improves productivity, and reduces costs

Over the past 5 years, studies across the United States have shown that GPS technology increases the productivity of conventional survey crews, reduces data collection time, improves survey accuracy, and allows crews to work under a broad range of weather conditions. Moreover, less expertise is required to operate a GPS surveying unit than is needed to operate conventional surveying technologies.

What is GPS?
GPS is a space-based, radio-navigation system that provides worldwide, all-weather, three-dimensional position, velocity, navigation, and time data to both civilian and military users. Potential uses for GPS within the highway community are diverse and range from providing traveler information to mapping (GPS technology can be integrated easily with Geographic Information Systems).

How does it work?
GPS can provide a very accurate digital map of the highway infrastructure. The technology operates on the principle of triangulation—if the difference from an observer to three known points can be measured, the position of the observer can be calculated. The system includes at least 24 satellites in orbit 19,320 kilometers (12,000 miles) above the earth and inclined at 55˚. These satellites continuously broadcast their position, a timing signal, and other information. By combining the measurements from four different satellites, users with receivers can determine their 3-dimensional position, currently within 4–20 meters (13–66 feet).

Successful Applications: Research indicates improved survey accuracy and reduced costs

The Utah Department of Transportation found that one person operating GPS equipment is generally twice as fast as a conventional survey crew, and a GPS system with two units is potentially four times faster than crews using conventional surveying technologies. Other advantages of GPS technology include the ability to use the technology across long distances with minimal setups. After a GPS system is placed, roving can be performed within a radius of 10 kilometers (6 miles) of the stationary base unit. Using conventional technologies, the base unit would have to be moved every 183 meters (600 feet). In one study, GPS equipment recorded 5,511 topographic points in 30 person-hours, while a similar project using conventional technologies covered only 1,500 topographic points in 120 person-hours.

Utah, Michigan, and North Carolina are the lead States of the American Association of State Highway and Transportation Officials' Technology Implementation Group (TIG) initiative to champion GPS for surveying applications. Plans include hands-on demonstration workshops and training programs for agencies that plan to apply GPS to surveying efforts. The GPS TIG group also is considering developing national standards and protocols for GPS programs.

Benefits

Compared to conventional surveying technology, GPS:

- Is faster.
- Requires less labor.
- Requires less training.
- Is more accurate.

Additional Resources

Additional information on GPS surveying technology is available at **www.aashtotig.org**

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Ground-Penetrating Radar

Problem: Highway pavement assessment generates significant maintenance costs

A significant portion of the cost of maintaining the highway system goes to determining the remaining service life of pavements and highway structures such as bridge decks. One of the greatest challenges in rehabilitating pavements is determining what is causing them to deteriorate and selecting the most appropriate rehabilitation measures.

How are pavements tested?
Traditionally, highway engineers have used such techniques as drilling core samples out of the pavement to establish layer thickness and determine what conditions beneath the road surface are causing it to deteriorate.

What are the disadvantages?
Conventional processes for taking core samples are labor intensive, require lane closures, and create potential safety hazards for highway workers and the traveling public. Extracting pavement cores and analyzing them at an offsite laboratory can be time consuming and expensive.

Solution: Ground-Penetrating Radar surveys pavements quickly and inexpensively

Using ground-penetrating radar (GPR) technology, highway engineers can assess subsurface conditions at a fraction of the cost of conventional methods. GPR systems survey pavements quickly and with minimal traffic disruption and safety risks.

What is GPR?
GPR technology is a field survey method that creates a cross-sectional image of the pavement subsurface. It is a pulse-echo technique for measuring pavement layer thickness and other properties, such as moisture content.

In a GPR system, antennas mounted on a moving vehicle transmit short pulses of radio wave energy into the pavement. As this energy travels through the pavement structure, echoes are created at boundaries of dissimilar materials, such as at an asphalt-base interface. The strength of these echoes and the time it takes them to travel through the pavement can be used to calculate pavement layer thickness and other properties.

Why use GPR?
GPR surveys can be conducted anywhere. The survey equipment is mounted on a vehicle that can travel at normal highway speeds, so lane closures are not required, traffic is not interrupted, and highway workers are not exposed to safety hazards. The equipment is compact and easily transportable.

GPR has a variety of applications, including assessing freeze-thaw damage, evaluating deterioration, measuring overlay thickness, and maintaining quality control of steel reinforcing bar placement.

Successful Applications: States use GPR to survey pavements and bridge decks

The Strategic Highway Research Program, Federal Highway Administration (FHWA), and several State departments of transportation (DOT) have conducted studies demonstrating the advantages of using GPR technology. Several States-including Florida, Louisiana, Michigan, North Carolina, and Texas-use GPR in their pavement evaluation programs.

The Florida DOT acquired a GPR system to gather data on pavement layer thickness and base layer material properties for its pavement management inventory. The system can collect data at a rate of more than 322 kilometers (200 miles) per day.

The Arizona DOT used GPR to survey 135 bridge decks as part of a bridge inspection program. The project provided data on deck conditions and steel reinforcing bar depths on more than 0.139 million square meters (1.5 million square feet) of bridge deck. Results were available quickly and at an affordable cost. GPR allowed the State to test as many as 12 bridges a day without lane closures, traffic disruptions, or exposure of highway workers to safety hazards.

Benefits

- Rapid, nondestructive, cost-effective survey method.
- Real-time data collection.
- Numerous areas of application.

Additional Resources

More information on GPR, including a presentation on implementing a GPR program, is available at www.aashtotig.org/focus_technologies/gpr/.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Highway Rail Warning System

Problem: Collisions at railroad crossings cause injury and death

Every year thousands of trains and vehicles collide at railroad crossings. In 2002, these accidents caused 311 deaths and 859 injuries. The increased use of active warning systems could prevent many of these deaths and injuries. However, installing conventional technology at low vehicle-volume railroad crossings in rural areas is cost-prohibitive; it costs an estimated $100,000 to $150,000 to upgrade a railroad crossing using conventional technologies. These high costs are because many passive crossings in rural areas are miles from electric power lines.

Putting It in Perspective

- Highway-rail grade crossing collisions occur approximately every 90 minutes in this country.
- A motorist is 40 times more likely to be killed if involved in a vehicle-train crash than in any other type of highway collision.
- In 2002, there were more than 3,000 vehicle-train collisions.
- Crashes at passive crossings are more likely to be fatal than crashes at crossings with active warning systems.
- It would cost approximately $14 billion to upgrade the 90,000 passive crossings in the United States using conventional technology.

Solution: Save lives with low-cost active warning technologies

What are low-cost active warning systems?
A low-cost active warning system typically consists of locomotive-installed hardware that communicates with railroad crossing warning devices to activate warning signals. The systems now being tested are able to upload and download data on all crossings within radio communication, and can also report on system operations health. Solar/battery powered flashing signs are mounted on standard crossing poles, and the system provides wireless communication between these devices and the train.

Successful Applications: The Minnesota experience

The Minnesota Department of Transportation (DOT), through the State's intelligent transportation systems program, Minnesota Guidestar, is partnering with the Federal Highway Administration (FHWA), the Twin Cities and Western Railroad, and the Federal Railroad Administration to evaluate a low-cost, Highway-Rail Intersection Warning System (HRIWS). The purpose of the study is to determine whether there are additional safety benefits from upgrading passive warning systems to active systems at selected rural railroad crossings. HRIWS:

- Provides automatic feedback about signal condition to the train crew so they can stop the train if signals are not working.
- Eliminates the need for connections to electric power lines through solar technology.
- Eliminates costly testing procedures through self-diagnostics that are triggered with each passing train.
- Avoids use of troublesome and costly track circuits.
- Requires no trackside infrastructure.
- Tracks train location through global positioning systems.

- Allows passing trains and crossing devices to communicate through digital radio receivers to determine whether all warning systems are operational.
- Warns motorists with receivers about approaching trains.
- Supports several trains at a single crossing.

Benefits

- Lower installation costs.
- High system reliability.
- Reduced maintenance costs.
- Designed for rural, low-volume crossings.

Additional Resources

Additional information about the Highway Rail Warning System is available at **www.aashtotig.org**

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

ITS Technologies in Work Zones

Problem: Work zones exacerbate growing highway congestion and safety concerns

With the National Highway System essentially complete, and many roads surpassing their useful design life, the focus of roadwork has shifted from new construction to rehabilitating and improving existing facilities. The share of capital funds used for system preservation rose from 47.6 percent in 1997 to 52.0 percent in 2000. As a result of this trend, transportation agencies must perform a greater number of projects on roads carrying traffic.

As vehicle travel continues to increase significantly faster than roadway miles, work zones exacerbate the growing congestion problem. Between 1980 and 2000, roadway lane miles increased 3.8 percent, while vehicle miles of travel grew 80 percent. From 1982 to 1999, "rush hour" increased from 2–3 hours to 5–6 hours a day. The time window for working on roadways without severely affecting traffic is getting smaller.

Putting It in Perspective

- Work zones account for nearly 24 percent of non-recurring congestion, or 482 million vehicle-hours of delay.
- In 2002, work zone fatalities reached a high of 1,181.
- More than 40,000 people are injured in work zone-related crashes each year.

Solution: Intelligent Transportation Systems (ITS) technologies improve traffic flow and increase safety in work zones

ITS technologies increasingly are being used to anticipate and mitigate congestion caused by highway work zones. These technologies provide ways to better monitor and manage traffic flow through work zones and increase safety for both workers and road users. By easing congestion and improving traffic flow, ITS technologies can reduce construction time and costs. ITS technologies also improve incident detection, response, and clearance in work zones; this is particularly important because traffic capacity often is reduced in work zones, and incidents in these areas cause even greater congestion and increase the potential for secondary crashes.

What are some examples of ITS technologies used in work zones?

ITS technologies are used in a variety of applications. For example, dynamic lane merge systems facilitate efficient and safe traffic merging as vehicles approach work zone lane closures. Speed advisory systems detect and display the speed of approaching vehicles to encourage drivers to slow down. Variable speed limit (VSL) systems detect occupancy, speed, and weather; the data are analyzed by a virtual traffic management center or field unit that uses the information to establish and display a condition-responsive speed limit on signs based on preprogrammed criteria. The data also helps provide real-time information to motorists through changeable message signs, Web sites, and traveler advisory radio alerts.

Successful Applications: Tackling work zone mobility and safety issues with ITS

Using a mobile traffic monitoring system on a full closure of U.S. Interstate 496 (I-496) in Lansing, MI helped the Michigan Department of Transportation (DOT):

- Identify and respond to incidents quickly, thereby minimizing the impact on traffic.
- Provide real-time information on problem areas to travelers.
- Communicate more effectively with local agencies.

The Illinois DOT used a portable traffic monitoring and information dissemination system to support bridge reconstruction activities on a busy section of I-55 near Springfield, IL. Benefits of using the system included:

- No significant backups.
- Fewer traffic citations in the work zone (dynamic information on the number of citations issued to date was posted upstream of the work zone).
- Only two crashes in the work zone over the first five months—one attributed to fatigue and the other to alcohol.

In 2002, the North Carolina Department of Transportation (NCDOT) deployed its first smart work zone during roadwork on I-95 just north of Fayetteville. Sensors collected traffic data and analyzed the data to estimate delay. When delay surpassed a pre-set threshold, the system automatically displayed alternate route information on electronic signs. Traffic condition information was also displayed on a Web site. Before the system was installed, whenever there were lane closures queues approaching the work zone were often several miles long and sometimes exceeded five miles. After the system began operating, the queues decreased to generally two miles or less. NCDOT noted that there were no fatalities associated with this work zone and fewer crashes as compared to previous I-95 road projects without ITS.

Benefits

- Ensures more efficient traffic flow.
- Increases safety for workers and road users.
- Provides real-time information to motorists.
- Reduces crashes and traffic delays.

Additional Resources

FHWA is working with State and local partners to sponsor "Making Work Zones Work Better" workshops. Information on the workshops is available at **http://ops.fhwa.dot.gov/wz/workshops/workshops.htm**.

The *Work Zone Best Practices Guidebook* covers success stories and lessons learned on topics such as ITS. Information on the guidebook is available at **http://ops.fhwa.dot.gov/wz/practices/best/bestpractices.htm**.

For more information about ITS work zone technologies, visit **http://ops.fhwa.dot.gov/wz/technologies/its.htm**.

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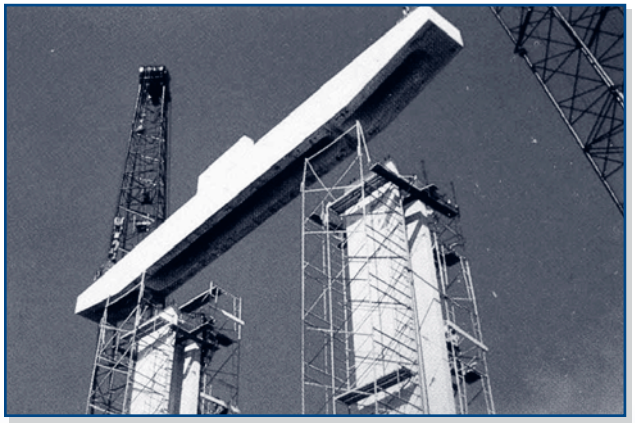
U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Prefabricated Bridge Elements and Systems

Problem: Bridge construction is a primary source of congestion

The traveling public has lost patience with the extensive highway construction that is necessary today. As the U.S. interstate highway system approaches the end of its service life, urban congestion continues to grow. Bridge construction or rehabilitation can be a significant source of congestion because of its sequential nature: foundations for piers and abutments must be built first, then pier columns and caps must be built before beams and decks are placed. Offsite prefabrication technologies and processes help solve this problem.



Prefabricated superstructure caps and columns

Solution: Prefabrication minimizes traffic disruptions

Prefabricated bridge elements can be manufactured either onsite or offsite under controlled conditions and brought to the construction location, ready for installation. Using prefabricated elements and systems minimizes construction-related traffic disruptions, increases work zone safety by reducing the number of and exposure time of workers operating near moving traffic, reduces environmental impacts by minimizing the site access footprint, and improves the constructability of bridge designs by controlling manufacturing environments. Innovative concepts including use of high performance materials can mitigate the frequent need for maintenance and resulting traffic impacts.

Substructures

A total substructure system consists of individual pier(s) or prefabricated bent cap supported by precast column(s).

Bent and Pier Caps

Cast-in-place bent and pier caps require extensive formwork and curing times, but if they are fabricated offsite, curing times are not a factor. As a result, bridge owners and contractors increasingly are turning to precast caps. Precast caps provide the following benefits:

- For over-water bridges, they reduce the amount of time that workers need to operate over water.
- For bridges over existing roadways, they minimize formwork required, which reduces traffic disruption on the lower roadway.
- For bridges with job site constraints, such as power lines that affect work zone safety, they limit the amount of time that workers are at risk.

Columns

Bridge construction times can be reduced significantly by using precast columns. Columns can be segmented, post-tensioned, reinforced, hollow, or solid concrete.

Superstructures

Increasingly, innovative bridge designers and builders are finding ways to prefabricate entire segments of the superstructure. This may involve prefabricated truss spans and preconstructed composite units that are fabricated or assembled at or away from the project site and then lifted into place in one operation.

Decks

Prefabrication offers exceptional advantages for deck construction, particularly for removing deck construction from the critical path of bridge construction schedules. Partial-depth prefabricated deck panels act as stay-in-place forms that help accelerate and control construction for decks that are more durable than fully cast-in-place decks. Full-depth prefabricated bridge decks also facilitate construction; bridge designers are finding innovative ways to connect full-depth panels.

Full-depth deck panels for the George Washington Parkway in McLean, VA

Total Prefabricated Bridge Systems

Total prefabricated bridge systems offer maximum advantages for rapid construction and depend on a range of prefabricated bridge elements that are transported to the work site and assembled in a rapid-construction process.

Benefits

- Increased work zone safety.
- Improved constructability.
- Lowered life-cycle costs.
- Increased quality through controlled fabrication conditions.

Successful Applications: Prefabrication benefits States

The Washington Department of Transportation (DOT) recently minimized traffic disruption on the U.S. Interstate 5 (I-5) /South 38th Street interchange in Tacoma, WA, by using partial-depth precast concrete deck panels.

When the Virginia DOT needed to keep I-95 open during the James River Bridge replacement, the State used a prefabricated superstructure system for most of the bridge spans. The composite units consisted of a 222 mm concrete deck over steel girders that were fabricated at a nearby casting yard. Crews were able to cut the old bridge spans into segments and remove them, prepare the gaps for the new composite unit, and then set the new unit in place in an overnight operation.

Ongoing research is focused on identifying and developing new bridge elements and systems for all materials that would help accelerate bridge construction.

Additional Resources

Visit the American Association of State Highway and Transportation Officials' Technology Implementation Group (TIG) Web site at **www.aashtotig.org** for more information on prefabricated bridge elements and systems or to learn about the TIG Implementation Panel on Prefabricated Bridge Elements and Systems' activities.

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U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Thermal Imaging Safety Screening System

Problem: Defective commercial vehicle brakes lead to roadway fatalities

In 2001, commercial vehicles (large trucks with a gross weight over 4,540 kilograms (10,000 pounds)) were involved in more than 409,000 crashes, resulting in more than 5,000 fatalities. In many cases, defective brakes and other vehicle-related safety problems are a factor in these crashes. Infrared brake screening technology can help identify maintenance needs before these deficiencies create problems on the road.

Putting It in Perspective

In 2001:

- Commercial vehicle crashes accounted for 12 percent of the year's total 42,116 fatalities.
- In 4,431 of these crashes, at least 1 person was killed; this is the fewest number of fatal crashes involving a large truck since 1996.
- In 86,000 crashes involving commercial vehicles, at least 1 person was injured.

Solution: Infrared brake screening technology is a proven, cost-effective method for detecting commercial vehicles with defective brakes

What is this technology?
Researchers have integrated infrared brake screening technology into the Infrared Inspection System (IRISystem), a minivan equipped with a rooftop infrared camera and an interior display screen. The IRISystem screens for brake defects and produces results in seconds.

How does it work?
As a commercial vehicle decelerates to enter a roadside inspection facility, an IRISystem inspector scans its wheels with a camera. The screen displays thermal images of the wheels, showing their relative temperatures. Because the application of brakes creates heat, the wheels with functional (warm) brakes appear bright white in the infrared image, while the wheels with inoperative (cold) brakes appear dark. The color image helps the operator easily identify a vehicle with functional or inoperative brakes.

The IRISystem can be used at various scale sites and other suitable inspection locations. To achieve effective results, the IRISystem should be placed at sites where commercial vehicles must apply their brakes to enter.

What are the limitations of the IRISystem?
Vehicles typically are screened at speeds less than 16 kilometers per hour (kph) (10 miles per hour (mph)), although experienced and skilled operators can screen vehicles moving as fast as 64 kph (40 mph). No useful results were obtained when mainline screening tests were conducted at 89 kph (55 mph).

Successful Applications: State studies demonstrate effective screenings

Four States—Kentucky, Georgia, North Carolina, and Tennessee—participated in a yearlong evaluation. States used the IRISystem primarily at scale sites on highways, where commercial vehicles could be screened and inspected easily. Most operators screened vehicles traveling less than 16 kph (10 mph), while experienced operators assessed vehicles moving as fast as 64 kph (40 mph). At each site, vehicles were screened by an IRISystem operator and then subjected to a standard Commercial Vehicle Safety Alliance Level 1 inspection. The Level 1 inspector was unaware of the IRISystem screening results.

Approximately 400 vehicles were screened by the IRISystem and subjected to a Level 1 inspection. To improve the study's objectivity, 62 vehicles with no apparent problems (according to IRISystem operators) also were selected for Level 1 inspections. These non-problematic vehicles represented 16 percent of the total population of commercial vehicles tested. Approximately 70 percent of the vehicles inspected were loaded with cargo.

The study showed that the IRISystem could be used effectively to screen commercial vehicles for inspection of brake-related problems. Kentucky established an effectiveness criterion that 50 percent of the vehicles identified by the IRISystem as problematic should be confirmed as defective by the Level 1 inspection. All four States met this criterion. Overall, 59 percent of the vehicles identified as problematic by the IRISystem were placed out-of-service for brake violations. The study further revealed that brake defects or deficiencies on a commercial vehicle often indicated that other repairs were needed.

Benefits

Infrared brake screening technology:

- Detects commercial vehicles with defective brakes in real-time.
- Evaluates vehicles moving as fast as 64 kph (40 mph).
- Identifies problems accurately—69–76 percent of the wheels that the IRISystem identified as problematic were confirmed defective by the Level 1 inspection.

Additional Resources

For additional information on this technology, visit the American Association of State Highway and Transportation Officials' Technology Implementation Group Web site at **www.aashtotig.org** or the Federal Motor Carrier Safety Administration Web site at **www.fmcsa.dot.gov**.

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