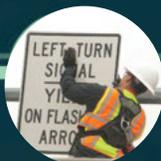


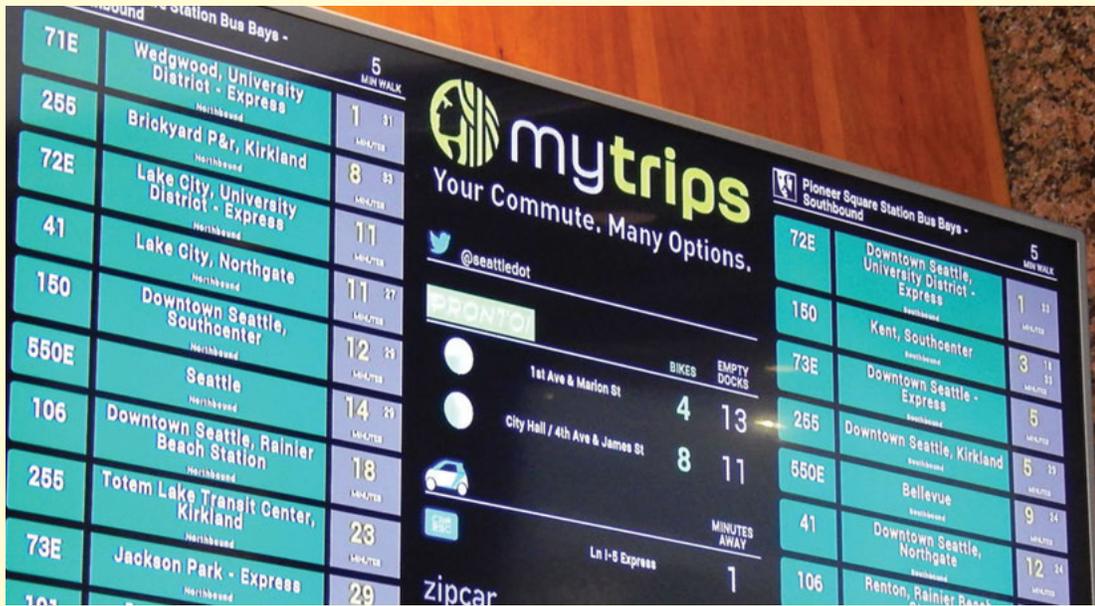
Findings from the Transportation Research Board's
2014 State Partnership Visits Program

TRENDSETTERS IN TRANSPORTATION TECHNOLOGIES



Specialists in the Transportation Research Board's (TRB's) Technical Activities Division identify current issues, collect and generate information on the issues, and disseminate the information throughout the transportation community. The TRB Annual Meeting, TRB-sponsored conferences and workshops, webinars, standing committee meetings and communications, publications, and contact with hundreds of organizations and thousands of individuals provide TRB staff with information from the public and private sectors on all modes of transportation.

A major source of this information is the TRB annual state partnership visits program. Transportation professionals on the TRB staff meet on site with representatives of state departments of transportation (DOTs) and with representatives of universities, transit and other transportation agencies, and industry. In addition, TRB staff is involved with planning and delivering conferences, workshops, webinars, and meetings. This report summarizes what the TRB staff learned from visits and activities during the past year.



The lobby of the Municipal Tower in Seattle, Washington, contains the TransitScreen display, a real-time schedule of nearby transit options.

U.S. transportation agencies are accelerating the deployment of new and advanced technologies to improve operations and services to customers. These deployments cover a range of responsibilities and modes. Examples include the following:

- ◆ Enhancing performance management and asset management with innovative data collection and management tools to achieve strategic goals;
- ◆ Tapping the Global Positioning System (GPS)

and other technologies to test the feasibility of new financing options such as mileage-based user fees;

- ◆ Merging key databases to build knowledge and information management systems;
- ◆ Increasing the use of recycled materials for highway construction and maintenance;
- ◆ Applying remote sensing to improve imagery and to reduce response time to natural disasters;
- ◆ Deploying innovative data collection technologies to integrate data across all modes;
- ◆ Preparing for connected-automated vehicles, shared ride services, and unmanned aerial systems—including development of new laws and regulations;
- ◆ Harnessing new technologies to improve and manage truck parking;
- ◆ Providing long-life pavement with continuously reinforced concrete, roller-compacted concrete, and other advances in concrete technologies to accommodate heavy traffic loadings, such as those related to the domestic energy boom;
- ◆ Collecting information for rock slope evaluations with remote sensing technologies;
- ◆ Improving highway safety by implementing the data-driven tools specified in the *Highway Safety Manual*; and
- ◆ Supplying applications for customers to view the real-time performance of transportation modes and services.



The U.S. Geological Survey's Spider tool uses remote sensing technology to survey rock slopes safely.

As the following reports show, state DOTs and other transportation organizations are working to ensure a high return on investment from limited resources by deploying advanced technologies and implementing innovative solutions to transportation problems.



Taxi drivers protest the city of Chicago, Illinois, granting a license in May 2014 to ridesharing company Uber, which relies on smartphone apps.

Institutional Issues

Policy, Management, and Leadership

State transportation agencies increasingly are applying technology to achieve strategic and policy goals in a variety of areas—asset management and performance measures are common themes. North Dakota DOT, for example, is implementing a new strategic plan that provides detailed objectives, goals, and baseline performance targets at the department and division levels.

California DOT (Caltrans) is approaching the challenge of data needs from several perspectives. The agency's Division of Research, Innovation, and System Information developed a strategic plan through 2016 for information and knowledge management, now in implementation. Caltrans is working to develop the information technology architecture for such tasks as merging key databases and recording assets via light detection and ranging (lidar) technology, to achieve the accurate transfer of data from design to construction to maintenance. Caltrans also is working to implement a pilot program to evaluate mileage-based user fees within the state's road network.

Planning

Planning agencies are working to leverage a range of technologies to improve transportation infrastructure, traveler information, and data collection. For example, the Vermont Agency of Transportation is gathering and centralizing information about transit service across the state. The database will augment the Google transit trip planning service offered by three transit agencies.



PHOTO: CALTRANS

The California Department of Transportation deploys its Mobile Terrestrial Laser Scanning Vehicle to gather surface data to support its information and knowledge management strategic plan.



PHOTO: CALEB KENNA PHOTOGRAPHY

The website for Addison County Transit Resources in Vermont offers Google transit trip planning capability for users.

The Vermont Agency of Transportation also is working with other state organizations to promote electric transportation. Drive Electric Vermont provides educational outreach to municipalities, developers, business owners, and the driving public.

Illinois DOT is researching recycled materials in many settings and is using more recycled materials in highway construction and maintenance. Illinois DOT has revised specifications, policies, and procedures, resulting in a fourfold increase in tons of recycled materials per mile from 2009 to 2013.

Working with U.S. DOT, many state DOTs are exploring remote sensing technologies to improve imagery and to decrease response time to natural disasters. The additional and timely information can make the response safer and can help in coordinating the response and the data collection by local and state agencies.

Legal Issues

Alternative methods of project delivery, jurisdictional differences in the procurement authority for each method, and the effective resolution of disputes under these methods are pressing issues in construction contract law. Issues that receive routine treatment under typical project delivery sometimes present special challenges in the context of alternative project delivery—for example, satisfying disadvantaged business enterprise requirements and delays of claims.

Public-private partnerships (P3s) present the most challenging issues, because funding is involved. The increased consideration of P3 projects may be a result of the high cost of projects and the unpredictability of federal and state funding. P3 initiatives, as well as new tolling systems, are under active development, and tax alternatives, such as mileage-based user fees, are attracting interest.

The Federal Highway Administration (FHWA) has devoted considerable attention to implementing provisions in the Moving Ahead for Progress in the 21st Century Act (MAP-21) on environmental reviews for highway and transit projects. The key provisions address the following:

- ◆ Categorical exclusions that apply to operational right-of-way and to projects receiving limited financial assistance;
- ◆ The designation of new categorical exclusions and a reduction in the evaluation and documentation requirements for several other categorical exclusions;
- ◆ The use of planning decisions and studies in National Environmental Policy Act reviews; and
- ◆ Revised procedures for federal decision making and dispute resolution.

Environment, Energy, and Climate Change

Environmental managers are working to communicate the needs for environmental regulatory compliance on design-build projects. One state official explained: “The failure to meet regulatory requirements will be the downfall of design-build.”

PHOTO: JOHN WARD, I-95 EXPRESS TOLL LANES



States are continuing to struggle with increasingly strict stormwater management regulations, particularly for the use and safe storage of sodium chloride for deicing applications.

States are devoting more efforts to climate change adaptation plans and to long-term infrastructure investments. With state budgets decreasing, the plans are analyzing the repair or rebuilding of storm-ravaged roads, as well as the benefits of new technologies.

Other issues include the maintenance of oil and gas industry roads; roadway dust suppression techniques to minimize the impacts on air quality; managing roads that are deemed historic; and improving the alternative fuel infrastructure to increase public use and environmental benefits.

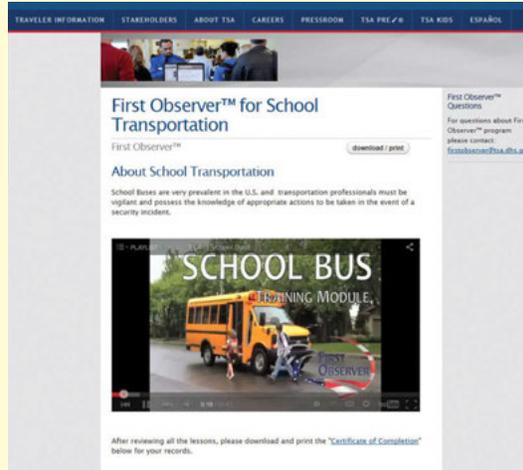
High-occupancy toll lanes on I-95 in Maryland, the product of a public-private partnership, opened in December 2014.

PHOTO: LARRY CARUSO, PHOTO EDITOR, NEWS-HERALD



A salt truck applies deicing material before a storm in Wayne County, Michigan. Strict stormwater regulations have caused state DOTs to examine deicing applications that use sodium chloride.

The Transportation Security Administration's First Observer training program features modules for highway-related transportation professions.



Critical Infrastructure Protection and Security

States are recognizing the role of security and all-hazards emergency management in resilient transportation systems. In October 2014, the American Association of State Highway and Transportation Officials' (AASHTO's) Special Committee on Transportation Security and Emergency Management (SCOTSEM) held a National Peer-to-Peer Exchange and Best Practices Summit addressing resilience, emergency air operations, hazardous materials transportation, rail shipments of crude oil, and the national strategy for transportation security.

At the federal level, the Transportation Security Administration (TSA) released a training program, First Observer, for safeguarding national transportation systems against terrorism and other threats. With modules for all categories of highway-centric transportation occupations, the program focuses on

how to observe, assess, and report suspicious individuals, vehicles, packages, and objects and to communicate the information clearly via appropriate channels.

Cybersecurity remains a high priority within all parts of the transportation system. In June 2014, the Government Accountability Office released a report, *DHS Needs to Better Address Port Cybersecurity*, urging the U.S. Coast Guard to develop and undertake a comprehensive risk assessment of cyberrelated threats, vulnerabilities, and consequences in the maritime environment. The report also identifies shortcomings in information-sharing mechanisms between government entities and nonfederal stakeholders.

Data and Information Technologies

With active transportation on the increase, states are implementing data collection to determine the extent of bicycle and pedestrian activity, to adjust programs and support investments. Pennsylvania DOT has been working with the Delaware Valley Regional Planning Commission, the Philadelphia metropolitan planning organization, to implement innovative collection technologies and to integrate the data into the general traffic database. North Carolina is developing a statewide program for collecting data on nonmotorized transportation.

Understanding and communicating how transportation systems support state economies is fundamental in public relations. Market-oriented data can inform system decisions by indicating the function and value of a link. States like Iowa are working with freight flow information to understand the trans-

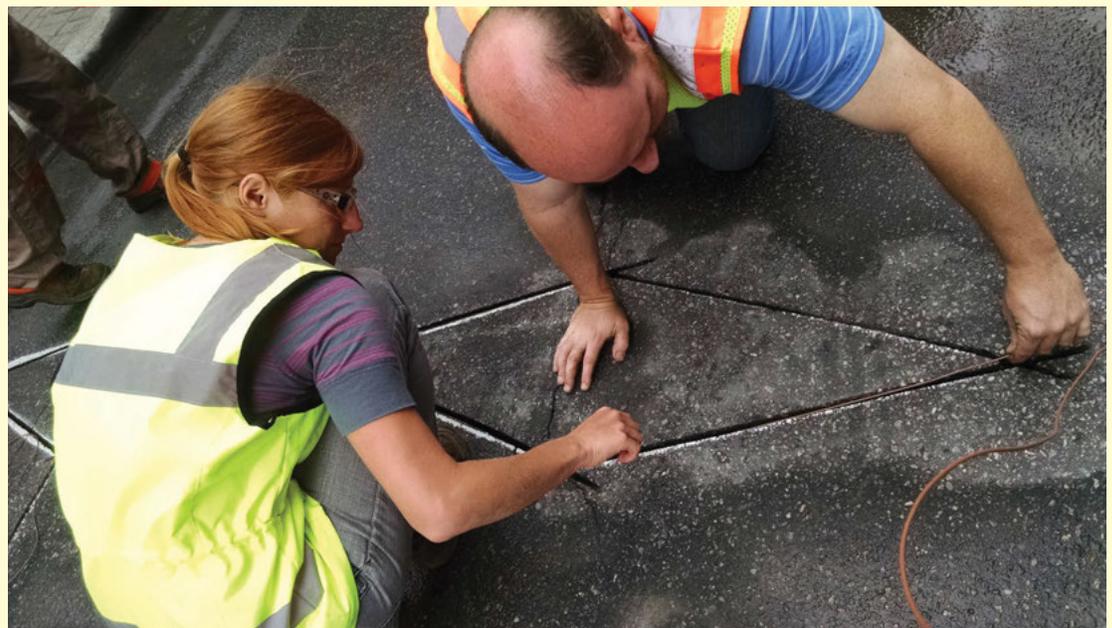


PHOTO: ELIZABETH STOLZ, SPRINKLE CONSULTING

North Carolina State University's Institute for Transportation Research and Education team members Kristy Jackson and Chris Cunningham wire the loop for a permanently installed bicycle counter on 4th Street in downtown Winston-Salem. The state is developing a data collection program for nonmotorized transportation.



portation infrastructure needs of the business community. States are looking forward to the release of the national freight transportation dataset from the 2012 Commodity Flow Survey.

State investments in data as an asset require an understanding of the data's use and quality. Alaska and Minnesota have engaged in business planning for data.

With enterprise systems supporting multiple customers within a state, management of data resources has gained importance, and many states are implementing data governance initiatives. Michigan DOT, for example, has a chief data steward, who works closely with other state departments on information technology, data, and geographic information systems. The Michigan Center for Shared Solutions, which "promotes technology-driven solutions across all levels of government," is a key partner. A National Cooperative Highway Research Program (NCHRP) project is preparing a data self-assessment guide for state DOTs.¹

Aviation

The Federal Aviation Administration (FAA) is drafting regulations to integrate unmanned aerial systems—also known as remotely piloted aircraft—into domestic airspace. Major questions loom for state aviation agencies, however, including their roles in monitoring and managing the activities.

Also at the forefront of discussions are ways to reduce general aviation accident rates, followed by reactions to the disappearance of a commercial aircraft in international airspace and to the airliner shot down over an active war zone. Additional issues include an application by an international carrier to operate within the United States, which would affect

long-standing cabotage laws; development of commercial spaceports to meet increasing demands from commercial space industries; and analyses of current and new funding mechanisms as FAA reauthorization nears.

Freight Systems

States are increasing the connectivity and capacity of their freight systems to bolster economic development. In September, Ohio DOT sponsored the Ohio Conference on Freight, highlighting the state's strategic importance in global logistics. Ohio DOT and the Ohio Rail Development Commission have supported the Norfolk Southern Heartland Corridor and the CSX National Gateway Corridor projects. Ohio DOT also has prioritized Interstate and highway connector improvement projects near the intermodal terminals associated with the major trade corridors connecting East Coast seaports with the Midwest and beyond.

Innovative programs at Maine DOT are providing incentives for multimodal freight. Maine DOT's Industrial Rail Access Program provides for \$2 million in state funds and a maximum cost-share of 50 percent for projects that encourage economic development through industrial rail access. Maine Port

Virgin Galactic spacecraft docked in the bay at Spaceport America in New Mexico. Commercial spaceports are responding to a growing interest in commercial space aviation.

Rendering of a containerized articulated tug barge—the first of its kind in the United States; the barge is being developed under the New England Marine Highway Project.



¹ NCHRP Project 8-92, Implementing a Transportation Agency Data Self-Assessment. <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3399>.



PHOTO: PAUL SUTWAIN, FLICKR

New hours-of-service rules for truck drivers have increased overnight parking demand at highway rest areas.

Authority, in partnership with McAllister Towing and the U.S. Maritime Administration, has designed the first U.S. containerized articulated tug barge. The purpose-built coastal vessel will support future container-on-barge service between Portland, Maine, and Newark, New Jersey.

The Federal Motor Carrier Safety Administration's new rules for truck driver hours of service have increased the demand for overnight truck parking. Many state DOTs are trying to manage truck parking with new technology that provides commercial vehicle operators with information about the availability of parking at rest areas and weigh stations.

Highways

Design

Stormwater management is a significant and challenging topic for state DOTs and other transportation agencies. Adequate consideration of stormwater at the project development stages is key.

In addition, erosion and sediment controls have become a national focus for the construction industry. National and state environmentalists have emphasized the need to reduce the amount of sediment-laden stormwater runoff that discharges into local waterways from construction sites.

In Alabama, Auburn University's Department of Civil Engineering teamed with the state DOT to establish the Auburn University Erosion and Sediment Control Testing Facility at the National Center for Asphalt Technology Test Facility in Opelika. The facility was designed and constructed to assist Alabama DOT meet environmental commitments to protect state waterways from polluted stormwater runoff from construction sites.

By adopting the tested and improved practices in Alabama DOT's standard specifications, designers and contractors can minimize the environmental impacts of sediment-laden stormwater. Researchers aim to improve the effectiveness of erosion and sediment control practices in the field and to develop new treatment techniques.

With funding challenges for replacing and preserving aging infrastructure, Rhode Island and Indiana DOTs are renewing emphasis on constructability reviews in the development and design processes. The reviews can reduce risk, protect limited funds, and improve projects.

Construction and Materials

State transportation agencies continue to explore alternative project delivery systems. Alliance contracting is a potential addition to the toolbox. An NCHRP synthesis project is expected to provide more information on this highly collaborative approach, not yet in use in the United States.²

State DOTs have concerns about setting contract goals for disadvantaged business enterprises and

² NCHRP Synthesis 20-5, Topic 45-16, Alliance Contracting: Evolving Alternative Project Delivery, <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3598>.



PHOTO: D. ALLEN COVER, VIRGINIA DOT

Virginia DOT employees set a precast concrete beam for the Route 360 Bridges project.

monitoring compliance on design–build and other alternative delivery projects. An ongoing NCHRP synthesis project is reviewing these issues.³

Several states have renewed interest in continuously reinforced concrete pavement for long-life service under heavy traffic loadings and in harsh environmental conditions. Roller-compacted concrete is also drawing interest and is under consideration in Texas and Louisiana for reconstructing low-volume roads affected by energy development.

Precast concrete pavement technology is gaining acceptance for rapid repair and rehabilitation of concrete pavements, as well as for heavily trafficked asphalt concrete pavements and intersections. Several agencies have used this technology in a variety of applications.

Some states are using concrete overlays to extend the service life of pavements. The use of self-consolidating concrete in precast, prestressed bridge elements has increased. An NCHRP project is developing guidelines for the use of self-consolidating concrete in cast-in-place highway bridge components.⁴ Florida has experimented with self-consolidating concrete in the accelerated replacement of pavement slabs.

State agencies are supportive of recycling and sustainability in materials and construction; however, many are seeking a comfort level in using greater amounts of reclaimed materials without sacrificing performance. NCHRP projects are addressing these concerns.⁵

Geotechnical Engineering

Increased precipitation in several regions has triggered geologic hazards such as landslides, debris flows, and rockfalls along transportation corridors. Washington, California, North Dakota, Wyoming, and Maryland are among the states that experienced landslides or rockfalls. The March 2014 mudslide on State Route 530, near Oso, north of Seattle, Washington, claimed the lives of more than 40 residents.

Maryland joined the large number of states assembling slope inventory systems to monitor hazards proactively. Several state DOTs are using remote sensing technologies to collect information for rock slope evaluations.

Sink holes are another natural hazard emerging as a concern along transportation corridors, partic-

³ NCHRP Synthesis 20-5, Topic 45-3, Current Practices to Set a Disadvantaged Business Enterprises Goal on Design–Build Projects, <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3580>.

⁴ NCHRP Project 18-16, Self-Consolidating Concrete for Cast-in-Place Bridge Components, <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2978>.

⁵ www.trb.org/NCHRP/NCHRP.aspx.

PHOTO: WASHINGTON STATE DOT



ularly in areas with carbonate bedrock, known as karst terrains.

More than a dozen states have plans to adopt AASHTO's specification for the intelligent compaction of soils, and more than two dozen states held workshops for practitioners on this emerging technology.

Florida, North Carolina, and Virginia have tested a new dynamic embedded data collector developed in Florida for monitoring pile installations and have shared their experiences to facilitate adoption of the method by other states. The method promises improvements in worker safety and in the quality of the installation.

Operations

The rapid development of automated and connected vehicle technologies has caught the attention of media, the public, and many state DOTs. These advanced technologies are expected to yield the next major breakthroughs in improved operations and safety. Federal and state agencies, the automobile industry, and other private-sector partners are researching the effectiveness and feasibility of these advanced vehicle technologies.

Washington State DOT crews direct traffic after a landslide sheared off part of US-20. Many state DOTs had to contend with rockfall and landslide events caused by heavier-than-normal precipitation in 2014.

Emergency and highway personnel respond to a pavement collapse on East 26th Street in Baltimore, Maryland. The landslide, caused by heavy spring rains and a weak retaining wall, extended the length of a city block and swallowed multiple trees and parked cars.



A diverging diamond interchange on US-15 in Louisa, Virginia, was designed to accommodate increased traffic exiting I-64.



PHOTO: JACK BELUHART, VIRGINIA DOT

In preparation for automated driving, a few states have enacted legislation allowing the operation of autonomous vehicles on roadways, and others are contemplating similar legislation. Variations in state legislation, however, can lead to conflicting regulations, which could slow the pace of testing and deployment.

To improve traffic operations and reduce crashes at intersections and interchanges, agencies have explored a range of new configurations shown to be successful. These include diverging diamond interchanges, continuous flow intersections, superstreets, Michigan lefts, J-turns, and others. Utah DOT has implemented most of these designs successfully in

the Salt Lake City area.

Incident management programs, designed to restore normal traffic operations as quickly as possible, to reduce the impacts for road users and to improve safety, have lacked training programs for responders. Tennessee DOT and the Tennessee Department of Safety and Homeland Security recently opened the Tennessee Traffic Incident Management Training Facility, the first of its kind in the United States, to teach best practices for the safe, quick clearance of major highway incidents. The facility features a section of Interstate-like roadway, ranging from two to six lanes, with a guardrail, a two-way interchange, and cable and steel barrier rail, as well as a section of two-lane highway and a full four-way intersection, for simulating a variety of crashes to train emergency responders in safe and efficient clearance techniques.

The Tennessee Traffic Incident Management Training Facility in Nashville, which opened in 2014, features a variety of roadways for training exercises, from an Interstate-like segment to a four-way intersection.



PHOTO: TENNESSEE DOT

Infrastructure Preservation

State DOTs are updating their maintenance management systems in preparation for the maintenance-related performance measures for pavement and bridge assets under MAP-21. The volume of the data to be collected is expected to increase, and state DOTs are working on tools to transform the data into useful information. Agencies are deploying more structural health monitoring systems; tablet-based, 3-D, wireless bridge inspection systems; remote technology for monitoring highway assets; simulation-based winter maintenance training; and processes to integrate the data from the variety of management systems.

Transportation agencies are exploring tools for managing nonpavement and bridge assets. The collection of condition information on these assets historically has relied on manual inspection, which is costly and time consuming. Michigan DOT compared manual data collection with aerial lidar and mobile, high-resolution photo imaging for 27 highway assets. The test indicated that remote monitoring technologies could reduce agency costs for data collection on nonpavement and bridge assets by 50 percent to 70 percent.

Safety

The United States has experienced a steady decline in the number of highway fatalities since 2005, with a dramatic decrease beginning in 2007. Nevertheless, highway fatalities and serious injuries remain a significant threat to public health, and transportation agencies are finding it increasingly difficult to continue the downward trend.

MAP-21 requires a focus on safety performance targets. Transportation agencies are making use of data-driven tools such as the *Highway Safety Manual*,⁶ the *Human Factors Guidelines for Road Systems*,⁷ and the Federal Highway Administration's Systemic Safety Project Selection Tool,⁸ and are increasing focus on local and rural roads and on safety culture for further reductions in fatalities and serious injuries.

⁶ www.highwaysafetymanual.org/Pages/default.aspx.

⁷ NCHRP Report 600, www.trb.org/Main/Blurbs/167909.aspx.

⁸ <http://safety.fhwa.dot.gov/systemic/fhwasal3019/>.

PHOTO: TIM GROZE, MICHIGAN DOT



A Michigan DOT pilot project tested remote sensing technologies to monitor highway assets. With asset extraction software, users can zoom in on multiple points in a single image.

Connecticut is exploring education and enforcement strategies that have the greatest potential to improve pedestrian and bicycle safety, targeting drivers as well as pedestrians and bicyclists, and is increasing attention on distracted driving and drugged driving. The state is developing a master plan examining input requirements and implementation approaches in the *Highway Safety Manual* for infrastructure improvements.

Oklahoma also is addressing impaired driving by establishing five regional teams for the prevention of driving under the influence, as well as offering incentives for ignition interlocks and focusing more on impairment with prescription and over-the-counter drugs. Other targeted safety efforts include installing rumble strips in work zones to reduce fatalities and serious injuries for workers and motorists.

Ports and Waterways

A rebounding economy and changes in international

PHOTO: PEDESTRIAN AND BICYCLE INFORMATION CENTER



A crosswalk and in-street yield sign in Branford, Connecticut. Pedestrian and bicycle safety initiatives are under way in Connecticut and other states.

Photo: Tim Boyle, U.S. Army Corps of Engineers



A Great Lakes Dredge and Dock Company hopper dredge works to remove approximately 400,000 cubic yards of material from the Delaware River near Philadelphia, Pennsylvania. Larger vessel sizes have required many infrastructure upgrades at ports and inland waterways.

shipping practices are creating a complex mix of problems leading to extraordinary delays at some of the largest U.S. ports. The operational issues include larger ship sizes; vessel bunching caused by cascading schedule slippages on liner service routes; carrier coordination at terminals; and truck and chassis availability. These issues, coupled with a drop in productivity during labor contract negotiations, delayed peak season shipments from West Coast trade gateways to retailers by up to two weeks in 2014.

States and seaports lauded the passage of the Water Resources Reform and Development Act, which authorized more than \$8 billion in navigation projects on U.S. waterways. Seaports commended the legislation for increasing the yearly authorization levels of the Harbor Maintenance Trust Fund, which supports channel maintenance dredging projects, with the goal of achieving full use of the funds by 2025. In recent years, only 50 percent of the \$1.8 billion in collected funds has been appropriated for federal navigation channel maintenance.

Inland waterways were affected by a change in the cost-share formula for the Olmsted Locks and Dam project on the Ohio River. This project has absorbed most of the Inland Waterways Trust Fund in recent

years and has prevented the funding and postponed the schedules for other lock and dam infrastructure needs in the United States. The change will free up more than \$100 million annually for other critical inland system projects.

Rail

Passenger Rail

Although Amtrak again set ridership and revenue records in Fiscal Year 2014, the growth rate was slower than in previous years. An unusually harsh winter and delays caused by freight train congestion were among the factors slowing growth.

In the Northeast Corridor, ridership between Washington, D.C., and Boston, Massachusetts, rose by more than 3 percent, to set a new record, and revenue grew by a robust 8.2 percent. Amtrak continues to be the nonautomobile mode of choice in the Northeast, carrying three times the number of riders as all airlines combined between Washington, D.C., and New York City.

Eighteen states provide funding to Amtrak for passenger service on more than 15 corridors, five of which carry more than 1 million riders annually. Six of these corridor services set ridership records in 2014.

Freight Rail

The shipment of intermodal containers, which overtook intermodal trailer shipments in the early 1990s, now outnumbers trailer shipments by more than 8 to 1. The movement of domestic intermodal freight surpassed international container movements for the first time in 2014.



Photo: Ryan Staveland, Fluor

A MARC train in Odenton, Maryland. Demand has risen for rail passenger services in the Northeast Corridor; Amtrak experienced a 3 percent increase.



A “hackathon” hosted by the New York Metropolitan Transportation Authority in 2013 encouraged young developers to create innovative transit applications using Google Transit Feed Specifications.

The growth of intermodal freight, particularly domestic intermodal, has contributed to the unprecedented financial performance of the U.S. freight rail industry in recent years. Along with this intermodal growth, energy-related freight shipments have helped to offset the decline in coal movements.

This growth, however, comes at the price of increased congestion. Despite increased hiring and capital expenditures, the shortages of track capacity, manpower, and equipment continue to cause delays in rail freight shipments.

Public Transportation

Technology is having a profound effect on public transportation, from services to operations and maintenance. Real-time service information is increasingly available online and on smart mobile device applications. Google Transit Feed Specifications, for example, provide data on transit routes and schedules in an interactive, mapped format on agency websites and mobile applications.

Agencies such as the San Francisco Bay Area’s Metropolitan Transportation Commission are supplying sophisticated apps that enable customers to see the real-time performance of a variety of transportation modes and services to reach their destinations, from walking to transit to parking. Other innovations include coordinated fare collection among multiple service providers and using smart card data to inform operations planning and analysis.

Services are undergoing profound changes. The willingness of the millennial generation to share information also extends to rides. Shared-ride service providers such as Uber, Lyft, and Carma are appearing in cities throughout the United States and around the world, demonstrating a willingness to share car rides if the price and convenience are acceptable.

These market innovators are challenging long-

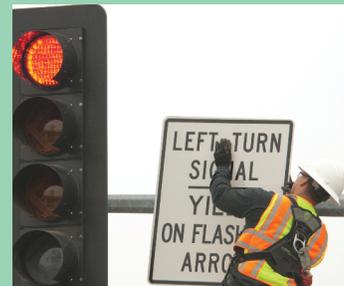
standing industries such as taxis, paratransit, and shuttle services to be more inventive and responsive to remain competitive and viable. At the same time, regulators are looking to protect the safety, security, and quality of privately offered public transportation services.

Enhancing and Advancing

TRB salutes the transportation organizations, leaders, and innovators who—as the examples in this report demonstrate—are working to enhance the delivery of transportation systems and services. TRB will continue to disseminate research and information on advanced technologies and related developments across the areas covered by its programs and activities.

Did You Know?

- ◆ Iowa is the only U.S. state with eastern and western borders defined entirely by rivers.
- ◆ Tennessee and Missouri have the highest number of bordering states—each has eight.
- ◆ Light-emitting diodes (LEDs) in traffic signals have saved transportation agencies money through the reduced consumption of electricity and a longer bulb life. LEDs do not waste energy by radiating heat, like incandescent bulbs, but this efficiency creates a problem in snow—the lights do not melt the snow that accumulates on the bulbs. Transportation agencies are finding signal design adjustments to overcome the problem, an example of the unintended consequences that can accompany technological advances.



Missouri DOT personnel install energy-efficient LED traffic signals installed at the intersection of Route F and Westminster in Fulton.