TR News January-February 2014: ABCs of Bridge Renewal

DETAILS

64 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-40273-6 | DOI 10.17226/22415

AUTHORS

Transportation Research Board

TR NEWS

NUMBER 290 JANUARY–FEBRUARY 2014

3 Snow States Pool Funds to Solve Winter Maintenance Challenges: Clear Roads Research Produces Immediate, Practical Applications
Wes Alwan and Patrick Casey

Every winter, transportation agencies face the logistical challenge of clearing ice and snow to keep roads passable and safe. The Clear Roads program leverages state member contributions to fund research into new techniques and technologies, avoid duplication of effort, influence the private sector, engage in technology transfer, inform the public, partner with other research groups, and more.

11 Partners in Performance Management: Findings from the Transportation Research Board's 2013 State Partnership Visits Program

U.S. transportation organizations, leaders, and innovators are working to enhance the performance of transportation systems and services, fulfilling and complying with requirements in the Moving Ahead for Progress in the 21st Century Act. A summary of findings from the TRB annual state partnership visits offers details and highlights.

25 Innovative Bridge Designs for Rapid Renewal: SHRP 2 Project Develops and Demonstrates a Toolkit
Bala Sivakumar

To encourage states to implement accelerated bridge construction (ABC) techniques, a project of the second Strategic Highway Research Program developed standardized design approaches for constructing complete bridge systems under renewal with minimal disruptions to traffic. Pilot projects in Iowa and New York State have successfully applied the guidance in the ABC Toolkit.

30 Bridging a Creek, Entering the Mainstream
Ahmad Abu-Hawash

33 Innovations Slide into Place in New York State
William J. Gorton and Nicolas A. Choubah

34 Bridging Long Beach into the Future: Planning, Financing, and Building a Transportation Megaproject
Eric C. Shen

The State of California is replacing the Gerald Desmond Bridge, a steel-arch structure over the main channel of the Port of Long Beach, with the state's first cable-stayed bridge. The author explores the bridge's national and local significance, describes the features of the new design, and presents the megaproject's funding, policy, and engineering challenges.

39 Energy Sector Impacts on Road Infrastructure in Texas: Wind Power, Natural Gas, and Oil Production Driving Traffic
Jolanda Prozzi, Ambarish Banerjee, Sergey Grebenschikov, and Jorge Prozzi

Increased production of oil, natural gas, and wind energy has placed demands on the Texas transportation system. Roads facilitate the moving of components during the construction and development of an energy source and subsequently of some of the products. The authors present findings from a study for the Texas Department of Transportation that illustrate and quantify the impacts.

44 Ethanol Production and Wind Energy: Challenging Low-Volume Roads in Iowa
Mark J. Nahra

46 Repairing Damaged Rural Roads in Pennsylvania: Gas Companies Learn to Add Environmental Sensitivity to Durability
Tim Ziegler

3

11

34

COVER: States are implementing research findings to improve infrastructure performance and safety and reduce expenditures. New York State Department of Transportation piloted accelerated bridge construction techniques on I-84. (Photo: Copyright Andy Ryan, courtesy of HNTB)

TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

***TR News* is produced by the Transportation Research Board Publications Office**
Javy Awan, Editor and Publications Director
Lea Camarda, Associate Editor
Jennifer J. Weeks, Photo Researcher
Juanita Green, Production Manager
Michelle Wandres, Graphic Designer

TR News (ISSN 0738-6826) is issued bimonthly by the Transportation Research Board, National Research Council, 500 Fifth Street, NW, Washington, DC 20001. Internet address: www.TRB.org.

Editorial Correspondence: By mail to the Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, by telephone 202-334-2972, by fax 202-334-3495, or by e-mail jawan@nas.edu.

Subscriptions: North America: 1 year $60; single issue $12. Overseas: 1 year $85; single issue $12 plus shipping. Inquiries or communications concerning new subscriptions, subscription problems, or single-copy sales should be addressed to the Business Office at the address below, or telephone 202-334-3216, fax 202-334-2519. Periodicals postage paid at Washington, D.C.

Postmaster: Send changes of address to *TR News*, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001.

48 NEW TRB SPECIAL REPORT
Effects of Diluted Bitumen on Crude Oil Transmission Pipelines
Thomas R. Menzies, Jr.
The Pipeline and Hazardous Materials Safety Administration requested a study to examine the chemical and physical properties of bitumen diluted for pipeline transportation and any evidence that diluted bitumen would increase the likelihood of a pipeline failure and release. The findings suggest that diluted bitumen will not cause pipeline releases at a rate higher than that of other crude oils.

ALSO IN THIS ISSUE:

51 **Research Pays Off**
Effective Use of Chip Seals in Minnesota
Melissa K. Cole and Thomas J. Wood

53 **Calendar**

54 **Profiles**
Transit researcher and institute director Dennis P. Hinebaugh and traffic operations and safety consultant Wayne Kittelson

56 **TRB Highlights**
Cooperative Research Programs News, 58

59 **News Briefs**

60 **Bookshelf**

51

COMING NEXT ISSUE

A photographic essay highlights TRB's 93rd Annual Meeting, which featured a major policy address by U.S. Secretary of Transportation Anthony Foxx and set new attendance records. A related article reviews the history and legacy of the TRB Annual Meeting, which is moving to the Washington Convention Center in 2015 and beyond. Other articles offer insights into performance management issues and practice, new applications of research on bridge scour, enhancing research report distribution through social media, and more.

Anthony Foxx, U.S. Secretary of Transportation, addresses a standing-room-only audience at the TRB Annual Meeting, January 15. He noted the need for an "integrated national transportation plan" and reminded the attendees, "All of you are doers....Make our case to stakeholders and communities."

PHOTO: CLEAR ROADS

Snow States Pool Funds to Solve Winter Maintenance Challenges

Clear Roads Research Produces Immediate, Practical Applications

WES ALWAN AND PATRICK CASEY

Alwan is a Senior Associate and Patrick Casey is CEO, CTC & Associates LLC, Madison, Wisconsin.

Every winter, transportation agencies face the enormous logistical challenge of clearing ice and snow to keep roads passable and safe for the traveling public. At the heart of the effort is technology—long gone are the days of horse-drawn snowplows, invented in the 1800s. Agencies today maintain fleets of winter maintenance vehicles equipped with a variety of technologies, from carbide plow blades to sophisticated computer systems that precisely determine the application rates of laboratory-formulated deicing chemicals.

By the early 2000s, states were making great progress in upgrading winter maintenance programs. In 1994 and 1998, international scans on winter maintenance practices had explored new equipment, technologies, and practices not yet used in the United States.[1] States were applying improved methods of weather forecasting in their maintenance deci-

[1] http://onlinepubs.trb.org/onlinepubs/circulars/ec013/1BSmithson.pdf.

(*Above:*) Since 2004, Clear Roads has focused on evaluating winter maintenance equipment and materials in the laboratory and on the field. Snow removal technology has progressed since 1908 (*below*), when teams of horses pulled snowplows down Chicago roads.

PHOTO: CHICAGO DAILY NEWS NEGATIVES COLLECTION, CHICAGO HISTORY MUSEUM

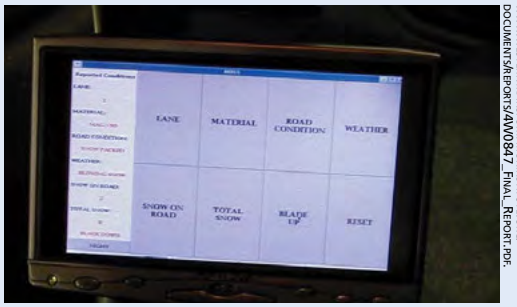
sion support systems, to target responses to weather-related road conditions.

A concept snowplow vehicle developed in the 1990s provided the foundation for the use of the Global Positioning System (GPS), automatic vehicle location systems, and other sensors to optimize snowplow operations. States also made advances in the chemistry of deicing materials, operator training, and other methods for improving the efficiency and environmental friendliness of winter maintenance (see *TR News*, November–December 2009[2]).

[2] www.trb.org/Publications/Blurbs/162781.aspx.

Developing Interface Specifications for Mobile Data Platforms

Many winter maintenance fleets use intelligent systems that allow control centers to track the location, health, and use of vehicles. The systems rely on the Global Positioning System (GPS), as well as on sensors that record plow usage, the application of salt or other deicing materials, the pavement temperature, the oil pressure, and other aspects of the vehicle's health.



WWW.WESTERNTRANSPORTATIONINSTITUTE.ORG/DOCUMENTSREPORTS/4WV0847_FINAL_REPORT.PDF.

Touch screen device in a snowplow cab; compatibility between the complex technologies on winter maintenance vehicles can be a challenge.

Integrating these control and monitoring systems has raised problems, often because vendors use proprietary communication protocols and data formats. Collecting data from different vendors' components into a single database can be difficult. As a result, most maintenance fleets use a single-vendor system, but this approach can limit upgrades to components and may require investing in an entirely new system when the vendor cannot provide the needed technology.

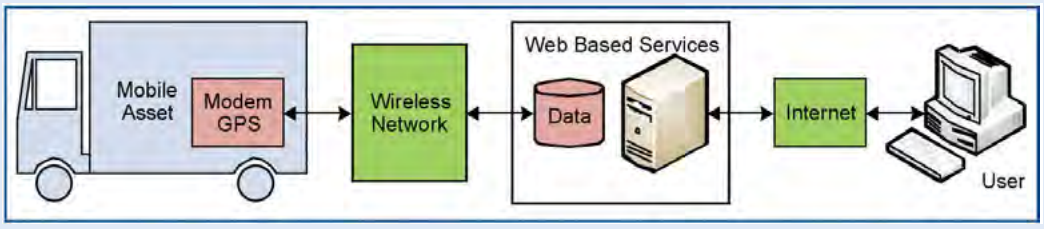
"State DOTs operate under a low-bid procurement process—a fleet easily can end up with 15 different kinds of controllers," observes Clear Roads Chair Dave Wieder. "The controllers need to be able to talk to each other and to work with newly purchased trucks."

A 2010 Clear Roads project has developed specifications for integrating sensors and other mobile data devices into a single system.[a] The proposed mobile data platform includes two types of wireless connectivity—wi-fi and cellular—and integrates GPS data with data from other sensors. These data can be sent in real time to a database for display via a web-based interface.

The specifications will simplify the process of adding new components to vehicles, ensuring competition among equipment vendors, and allowing users to build on their equipment inventories. The specifications also will reduce the costs of developing and maintaining a mobile data platform.

A follow-up Clear Roads project will develop testing software for approving plug-and-play technologies. "We're working toward equipment that interfaces seamlessly," Wieder reports. "Industry has listened and is working with us to make this a reality."

[a] http://clearroads.org/research-projects/08-02interface specifications.html.



A mobile data platform and data collection system includes an on-board modem and GPS unit and exports data from the vehicle's sensors via a wireless network to a database with a web-based interface.

Clear Roads focuses on practical outcomes, such as optimizing the rate at which salt and other deicing materials are applied to roads by winter maintenance vehicles.

Evaluating Technologies

But the advances in winter maintenance technologies and operations increased the challenge of evaluating effectiveness. How can a transportation agency know that the latest innovation proposed by a vendor or a researcher is actually an improvement?

With national and state winter maintenance organizations focusing research funds on the laboratory testing of materials and equipment, field research was needed to evaluate performance under conditions typically encountered by state DOTs.

Dennis Burkheimer, then winter operations administrator at the Iowa Department of Transportation (DOT), recognized this need and spearheaded the formation of an annual winter maintenance workshop in the Midwest in the early 2000s. The workshop served as a roundtable peer exchange for discussing successful technologies and practices.

In 2004, workshop participants decided to initiate a formal collaborative research effort under the Federal Highway Administration's (FHWA's) Transportation Pooled-Fund Program, establishing the Clear Roads Test and Evaluation of Materials, Equipment, and Methods for Winter Highway Maintenance.[3] Initial participants included Wisconsin as the lead state, Iowa, and Minnesota; Missouri and Indiana joined in 2005.

"Our interest was in testing equipment and materials in winter weather conditions, not just in the laboratory," notes Tom Martinelli, former winter maintenance engineer at Wisconsin DOT and the first chair of Clear Roads. "No one else was doing that."

The pooled-fund study grew significantly in the next six years, and members sought to expand the scope to include technology transfer and training. In 2010, the participating states reestablished the study as the Clear Roads Winter Highway Operations Pooled Fund.[4] The membership comprised 14 states, and Minnesota assumed the lead responsibilities. The focus is on practical outcomes, such as optimizing the rate at which winter maintenance vehicles apply salt and other deicing materials to roads.

"There was a need for research with immediate, practical applications," observes Dave Wieder, branch manager of maintenance and operations for Colorado DOT and current chair of Clear Roads. "How do you calibrate ground-speed-control spreaders to regulate deicing materials output? What is the best plow blade design?"

According to Martinelli, vendors were proposing alternatives to salt for deicing in the early 2000s, but uncertainty prevailed about the benefits in comparison with the costs. "Test procedures were needed to compare products, so that we wouldn't have to take the vendor's word on effectiveness," he explains.

Leveraging Research Dollars

Clear Roads leverages the contributions of its members—$25,000 a year—to fund research that states cannot afford on their own. "At Colorado DOT, our entire research budget is around $400,000 for six programs," Wieder explains. "We can't afford the kind of research possible through Clear Roads. Our $25,000 contribution gains more than $600,000 of winter maintenance research."

[3] TPF-5(092); www.pooledfund.org/Details/Study/317.

[4] TPF-5(218); www.pooledfund.org/Details/Study/446.

Calibration Accuracy of Ground-Speed-Control Spreaders

Transportation agencies are careful about controlling the amounts of salt, abrasives, and other chemicals applied to roads in winter. These materials have important benefits for safety but in excess can harm the environment and accelerate metal corrosion in vehicles and highway infrastructure. Overuse also leads to unnecessary expenditures from already overburdened winter maintenance budgets.

To regulate the delivery of treatments, the spreading systems on winter maintenance vehicles commonly are equipped with ground-speed controllers. This technology monitors the vehicle speed and automatically adjusts the rate of materials delivery to apply only the necessary amount. Before the development of controllers in the 1990s, truck operators used manual controls to adjust the delivery rate of salt or other materials.

How precise are these automated controllers, and do they perform better than manually controlled spreaders? Will a controller-equipped truck apply the same amount of salt per lane mile at 10 mph as at 45 mph?

In a 2008 Clear Roads project, researchers compared manual controllers against two types of ground-speed controller: open-loop systems, which monitor truck speed during operation, and closed-loop systems, which monitor both truck speed and spreader discharge and adjust the spreader speed accordingly.[a] Most of the seven controllers in the test could distribute solid materials, such as salt and sand, as well as liquid materials, such as brine.

A ground-speed controller in calibration mode.

The researchers reviewed DOT practices nationwide, calibrated controllers with the assistance of manufacturers, and conducted field tests to compare the intended to the actual discharge amounts of solid and liquid materials at a range of vehicle speeds and material application rates.

Results showed that automatic controller systems were superior to manual systems. Moreover, the study found that closed-loop systems can yield as much as 47 percent in materials savings at an application rate of 400 pounds of salt per mile. Closed-loop systems were much more accurate than open-loop systems, as expected, and the greatest savings were achieved in the stop-and-go conditions typical of urban environments.

The project also produced valuable hands-on calibration experience and led to the development of a spreader calibration guide,[b] including step-by-step procedures and checklists.

[a] www.clearroads.org/research-projects/05-02calibration.html.
[b] http://clearroads.org/research-projects/05-02calibration_files/Final-Calibration-Guide-02-09.pdf.

The Clear Roads goals have expanded into technology transfer, including a training video on the testing of deicing materials.[5]

Clear Roads also helps states avoid duplication of effort by producing solutions that take every state's needs into account and that influence the private sector. "Vendors will listen when 26 states ask for a solution," notes Mark DeVries, superintendent of the Division of Transportation for McHenry County in Illinois and liaison to Clear Roads for the American Public Works Association (APWA).

Each year, at a spring biannual meeting, members of the Clear Roads Technical Advisory Committee (TAC) submit research ideas for funding consideration. TAC members then vote to select five or six of the projects for funding; formal requests for proposals are developed for each project.

At the fall meeting, TAC members review the competing proposals and choose investigators to perform the projects. The TAC subsequently monitors the progress and ultimately approves the final reports and other deliverables.

Minnesota DOT, as the pooled fund's lead state agency, administers the contract agreements. The consultant firm CTC & Associates LLC provides administrative support for the research projects and for the TAC meetings, as well as technical communication services, including the study website, www.clearroads.org.

Rapid Growth

The goals of Clear Roads have expanded into technology transfer, including a training video on the testing of deicing materials.[5] In nine years, Clear Roads has grown from four to 26 members.

"More states are realizing that Clear Roads' work is offering solutions to day-to-day problems," says Lee Smithson, former deputy director of maintenance for Iowa DOT and liaison to Clear Roads for AASHTO's Snow and Ice Pooled-Fund Cooperative Program (SICOP). "States are interested in becoming part of the decision-making process for identifying research needs."

[5] www.youtube.com/watch?v=cIPTRCXRBDM.

As Clear Roads has grown and completed more projects, technology transfer efforts have become an important part of its mission. For instance, after developing a field testing guide for deicing chemicals, Clear Roads produced a related video for DOTs to use in training maintenance staff.[6]

This growth has also led to the logistical challenges of collaboration among a large group, and Clear Roads recently updated its operational procedures to accommodate the increasing number of participants. But this growth has made information exchange even more valuable; the Clear Roads distribution list serves as a resource on state winter maintenance practices.

"States can turn to members on various issues, from legislation to products," reports Tom Peters, maintenance research and training engineer for Minnesota DOT. "The pooled fund has improved communication among snow and ice states and between practitioners and decision makers."

Project Impacts

Clear Roads has completed 14 research projects, with seven more in progress and six to begin soon (see sidebar, page 8). These projects have produced practical solutions to common problems faced by snow and ice states. For example, an emerging technique, the direct application of liquid deicers during storms, had little field testing before a Clear Roads project.

One project developed a web-based analysis tool to help state maintenance managers calculate the benefit-to-cost ratio of selected winter maintenance technologies, including equipment, such as carbide blades, plows, and spreaders; deicing and anti-icing practices; and various systems critical to operations. With this toolkit, Iowa DOT determined that GPS on snowplows would yield a benefit-to-cost ratio as high as 10 to 1, saving millions of dollars. The project's recently completed second phase increases the number of winter maintenance materials, equipment types, and methods that can be analyzed.

A 2010 project identified the most effective methods and circumstances for the use of liquid deicers during winter storms, identifying pavement temperature, storm intensity, and storm moisture content as critical parameters. Applying the quick-reference guide and field testing guidelines, state DOTs are expanding the use of liquid deicers to save costs and reduce the environmental impacts.

Another project developed testing procedures to predict the performance of carbide inserts for snowplow blades. Many agencies found that the blades were wearing down quickly, requiring costly replace-

[6] www.clearroads.org/research-projects/10-01training-video.html.

Winter Safety Campaign Targets High-Risk Drivers

Winter weather can create hazardous road conditions. Many winter-weather crashes are preventable, however, if drivers are aware of the road conditions and develop the kinds of driving habits that winter weather requires.

Winter weather driving safety campaigns therefore are a key component of state and local transportation agencies' strategies for public safety. Yet the budget constraints of individual agencies often have limited the scope of safety campaigns.

Clear Roads member states decided to leverage their combined resources to create a professional campaign with a unified message targeting the most critical audience via the most effective formats. The Winter Driver Safety Campaign developed the now well-known slogan, "Ice and Snow … Take It Slow," along with a range of campaign materials that state and local agencies can customize for their winter safety programs.[a] Materials include logos, posters, videos, public safety announcements, flyers, and bumper stickers.

In 2010, Clear Roads conducted a follow-up effort to refine the campaign by learning about and targeting the high-risk drivers who would benefit the most from the message. Researchers analyzed highway crash data to identify the high-risk drivers typically involved in winter-related crashes and conducted an online survey of these drivers to evaluate the effectiveness of various message types.

From the findings, the researchers developed new campaign materials that built on the previous "Ice and Snow … Take It Slow" campaign. Also provided was guidance for the effective use of the new materials, including two Internet banner ads and a TV ad for use on air or on the weather-related pages of a local TV station's website in 30-, 15-, and 7-second segments.

The products from the project help transportation agencies make the most effective use of limited resources by customizing materials without having to develop original campaigns. Agencies also communicate and share the goal of reducing winter-related crashes, injuries, and deaths.

"These materials are more than we could have afforded on our budget in Colorado," notes Clear Roads Chair Dave Wieder. "Nearly every snow and ice state is using these materials to help increase the safety of the traveling public."

[a] www.clearroads.org/driver-safety-resources.html.

Analysis of crash data showed that failure to control speed was one of the leading causes of winter-related crashes.

Directly applying liquid deicers during storms is an emerging technique that had received limited field testing before a Clear Roads project.

ment. The standardized testing procedures have helped states purchase higher-performing blades and save on replacement costs.

"States spend a lot of money on snowplow blades," DeVries reports. "This project helped answer questions about which blades last longer and do a better job. The project results were implementable almost immediately."

Partnerships

Other organizations also conduct winter maintenance research, and memberships often overlap. To

The Clear Roads Project Portfolio

Research in Progress[a]

◆ Establishing Effective Salt and Anti-Icing Application Rates will update national guidelines for snow and ice control materials and methods.

◆ Understanding the Chemical and Mechanical Performance of Snow and Ice Control Agents on Porous or Permeable Pavements will determine optimal winter maintenance strategies for porous or permeable asphalt pavements.

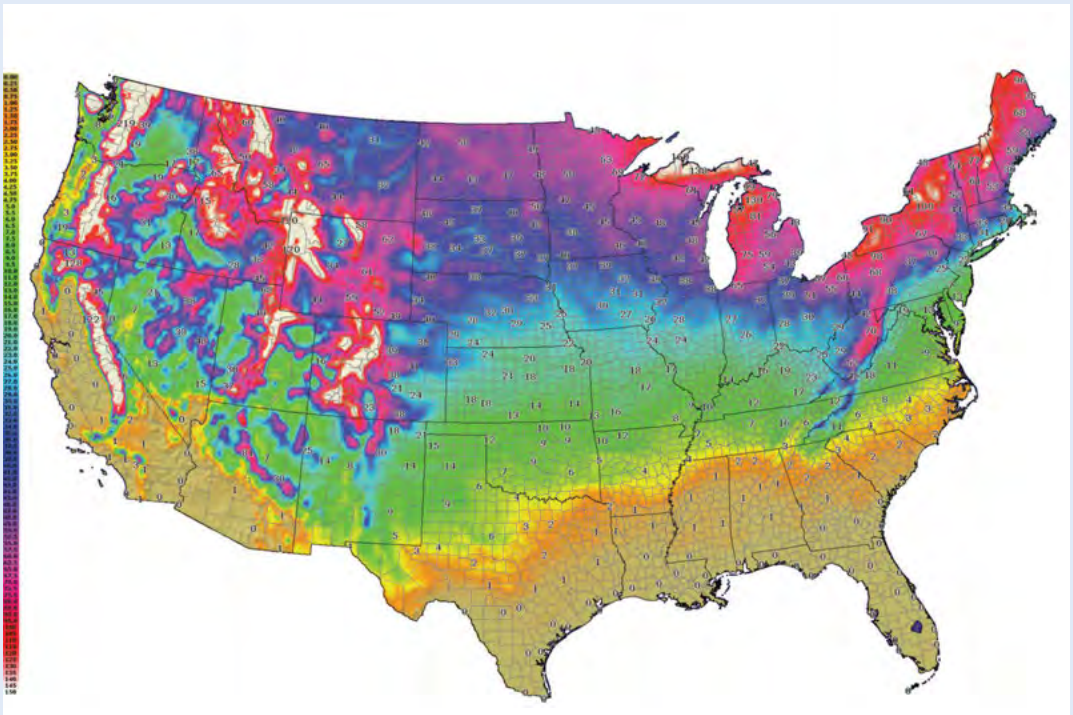
◆ Comparison of Materials Distribution Systems will catalogue and develop a field testing plan for solid materials distribution systems.

◆ Environmental Factors Causing Fatigue in Snowplow Operators will develop a series of cost-effective, realistic recommendations for reducing or eliminating equipment operator fatigue during winter operations.

◆ Determining the Toxicity of Deicing Materials will develop a quick-reference guide to the toxicity of deicing chemicals in several categories.

◆ Development of a Totally Automated Spreading System will evaluate the feasibility of a system for automatically dispensing deicing materials.

◆ Understanding the True Costs of Snow and Ice Control Operations will develop a tool to help winter highway professionals estimate costs for snow and ice removal, make cost comparisons with states that have similar climates and roadways, and consider new budget scenarios based on the successes of other agencies.



A recently completed project mapped the relative severity of winter weather across the United States; the results will facilitate understanding of each agency's snow and ice control costs. (Map generated by Meridian Environmental Technology for Clear Roads.)

avoid duplicating efforts, these organizations coordinate tasks and focus on different missions:

◆ The Aurora Pooled Fund Study aims at improving road and weather information systems,[7]

◆ The Winter Maintenance Committee of the Transportation Research Board (TRB) explores a range of winter maintenance research topics,[8] and

◆ AASHTO's SICOP identifies and evaluates the latest winter maintenance technologies, domestic and international.

Clear Roads complements these efforts by focusing on immediately implementable, short-term field testing. "In some cases, SICOP and TRB will give us an idea of what research needs to be pursued," Wieder reports. "In other cases, they conduct larger research projects that are outside our scope."

Through its collaboration with Clear Roads, Aurora gains insights into the kinds of data that road

[7] www.aurora-program.org/knowledgebase/Winter%20Operations.Default.aspx.
[8] www.trb.org/CommitteeandPanels/OnlineDirectory.aspx#DetailsType=Committee&ID=1593.

Completed Projects

◆ Cost–Benefit Analysis Toolkit, Phase II, expanded a previously developed toolkit for analyzing and justifying materials and equipment costs.

◆ Snow Removal at Extreme Temperatures reviewed best management practices for maintaining clear roads at extremely low temperatures.

◆ Mapping Weather Severity Zones developed a method for mapping winter weather severity across regions and states.

◆ Developing a Training Video for Field Testing of Deicing Materials produced an instructional video to demonstrate the three levels of field testing that determine the effectiveness of deicing chemicals.

◆ Development of a Toolkit for Cost–Benefit Analysis of Specific Winter Maintenance Practices, Equipment, and Operations produced a web-based tool for cost–benefit analyses of the components of winter maintenance programs.

◆ Identifying the Parameters for Effective Implementation of Liquid-Only Plow Routes described the circumstances and the most effective methods for using liquid deicing during winter storms.

◆ Development of Standardized Test Procedures for Carbide Insert Snowplow Blade Wear produced testing procedures to predict the performance of snowplow blade carbide inserts.

◆ Correlating Lab Testing and Field Performance for Deicing and Anti-Icing Chemicals, Phase I, laid the groundwork for developing a laboratory test to evaluate the performance and friction coefficient of deicing chemicals.

◆ Development of Interface Specifications for Mobile Data Platforms on DOT Vehicles determined specifications for plug-and-play integration of sensors and other devices with mobile platforms into DOT vehicles (see sidebar, page 4).

◆ Development of Standardized Test Procedures for Evaluating Deicing Chemicals established laboratory tests and procedures to identify the relative performance of deicers.

Snowplow operators often must work long shifts, and fatigue is a safety concern for transportation agencies. A Clear Roads research project is under way.

◆ Developing and Evaluating Safe Winter Driving Messages produced winter driving safety public service announcements and web advertisements targeting high-risk drivers (see sidebar, page 7).

◆ Determining Effectiveness of Deicing Materials and Procedures developed testing guidelines for evaluating the performance of various winter road chemicals.

◆ Calibration Accuracy of Manual and Ground-Speed-Control Spreaders developed guidelines to help snowplow operators establish and maintain accurate calibration of ground-speed controllers, reducing salt usage and improving efficiency (see sidebar, page 6).

◆ Synthesis of Best Practices for Eliminating Fogging and Icing on Winter Maintenance Vehicles conducted a comprehensive survey that identified effective methods for combating or preventing moisture on windows and mirrors while maintaining the comfort and safety of the plow operator.

[a] For links to full project descriptions, go to www.clearroads.org/research-projects.html.

A Clear Roads partner organization, the Pacific Northwest Snowfighters Association, is at the forefront of laboratory testing of deicing materials.

and weather information systems could collect that would be useful to winter maintenance programs. "The back-and-forth with the other groups makes for an effective balance," Smithson observes.

For example, input from APWA's Subcommittee on Winter Maintenance[9] provides Clear Roads with a practical city and county perspective on winter maintenance technology needs. "Local agencies often can try out new technologies and practices more easily than state DOTs, offering experience useful to Clear Roads," notes DeVries.

Interface with FHWA ensures a higher-level perspective for Clear Roads. "Keeping a clear line of communication between our agency and Clear Roads is helpful to both organizations," reports FHWA liaison Gabe Guevara.

Productive Collaborations

Clear Roads has engaged in productive collaborations with partner organizations. These efforts include:

◆ Maintaining materials testing and standards for deicing chemicals in support of the Pacific Northwest Snowfighters' widely used Qualified Product List;[10]

◆ With Aurora, developing a Wiki-style knowledge base for road weather and winter operations research and innovations,[11] to capture information—such as surveys of the salt specifications of member states—often not available in academic studies; and

◆ With SICOP, developing computer-based training modules for snowplow drivers and maintenance crews.[12]

[9] www.apwa.net/technical_committees/Transportation-Committee/Subcommittees/Winter-Maintenance.
[10] http://pnsassociation.org/.
[11] www.aurora-program.org/knowledgebase/Winter%20Operations.Default.aspx.
[12] http://sicop.transportation.org/Documents/CBT_Flyer_v2b[1].pdf.

Clear Roads also collaborates with SICOP and Aurora to organize the National Winter Maintenance Peer Exchange every two years to discuss winter maintenance research needs and innovations with all snow and ice states.[13]

Moving Forward

Research in progress by Clear Roads is addressing needs from updating National Cooperative Highway Research Program guidelines for snow and ice control materials and methods to the development of a totally automated spreader system (see sidebar, page 6).

Of particular note is a project to develop recommendations for reducing the fatigue of snowplow operators.[14] Researchers are currently surveying DOT management personnel and snowplow operators and are instrumenting operators to collect fatigue-related information. "Fatigue is a significant problem that needs a proactive solution," states Peters.

Another project is determining the toxicity of deicing chemicals. "Our watershed is small in Colorado," Wieder explains. "We have to be sure that the chemicals will not negatively affect the environment."

Upcoming projects include the development of a manual on environmental best management practices in snow and ice control, research into the effectiveness and environmental impacts of nonchloride liquid agricultural by-products in deicing, and establishing best practices to prevent the corrosion of DOT equipment from deicing chlorides. These projects continue the Clear Roads mission of providing practical solutions that can be implemented quickly and that are environment friendly.

"The emphasis at the federal level is on performance measures and environmental sustainability," Smithson observes. "Clear Roads is headed in this direction, working to determine what kinds of practices and equipment are necessary." With continued growth, Clear Roads can meet these goals with increasing effectiveness.

"My hope is that states that are not members will get involved in Clear Roads," Wieder notes. "The buying power of all snow and ice states can support research that benefits not only the maintenance personnel working tirelessly to keep us safe, but also the traveling public that must get from point A to point B in winter weather."

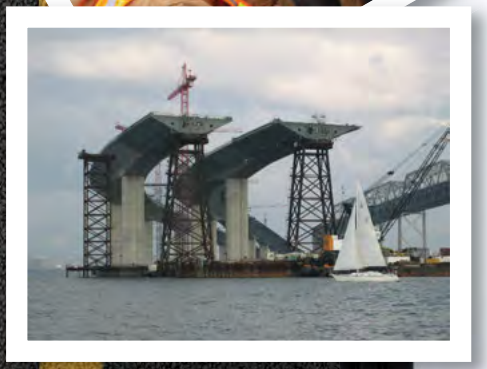
[13] www.westerntransportationinstitute.org/professional development/national-winter-maintenance-peer-exchange.
[14] www.clearroads.org/research-projects/11-05 environmental-factors.html.

PHOTO: IDAHO DOT

The environmental effects of anti-icing and deicing practices are a major concern for state DOTs.

Partners in Performance Management

Findings from the Transportation Research Board's 2013 State Partnership Visits Program



Specialists in the Transportation Research Board'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, 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, and meetings. This report summarizes what TRB staff learned from visits and activities during the past year.

Photo: West Virginia DOT

Crews repair a bridge deck in West Virginia. Pavement condition and other state DOT initiatives are subject to performance measurements required by MAP-21.

According to the December 2013 Fiscal Survey of States, "state budgets are slowly improving, but when … the impacts of inflation [are factored in], spending and revenue are both still below their prerecession peaks."[1] The report forecasts that growth in state revenues and spending in 2014 will continue below historical averages.

In recent years, with limited resources, many state departments of transportation (DOTs) have relied increasingly on performance management and measurement to guide and manage programs. Moving Ahead for Progress in the 21st Century (MAP-21), the federal surface transportation legislation passed in 2012, establishes a performance- and outcome-based approach for states to measure performance in the context of collective progress toward national goals.

MAP-21 requires state transportation agencies to measure and gauge performance from the condition of roadway pavement to improvements in safety. Although experiences and approaches vary among states and agencies, performance management—and the underlying data programs required—is defining transportation institutions in the 21st century.

State DOTs and other transportation organizations are working to ensure a high return on investment from limited resources by adopting performance management techniques and by implementing innovative solutions.

Institutional Issues

Policy, Management, and Leadership

With performance-based management a key tenet, U.S. DOT is promulgating performance requirements through a series of nine rulemakings scheduled in several phases.

[1] http://www.governing.com/topics/finance/State-Budgets-Improving-But-Growth-Still-Below-Historic-Rates.html.

Washington State DOT initiated an agencywide performance reporting process in 2001. A quarterly report, the *Gray Notebook*, provides system performance and project delivery updates on six policy goals: preservation, safety, mobility, environment, stewardship, and economic vitality.[2] With more than a decade of experience in measuring and managing performance, Washington State DOT is well positioned to meet the forthcoming MAP-21 requirements.

In Tennessee, state DOT employees rely on the *Performance Measurement Reference Guide*, which defines what the agency is measuring, how the results are collected and calculated, and why it matters.[3]

[2] www.wsdot.wa.gov/accountability/graynotebook.pdf.
[3] www.tdot.state.tn.us/osp/pdfs/TDOTReferenceGuide Definitions.pdf.

Photo: Washington State DOT

The *Gray Notebook*, Washington State DOT's quarterly performance report, judges such performance measures as the safety of rest areas, including the new electric vehicle charging station at the Gee Creek rest area on I-5 near Vancouver, Washington.

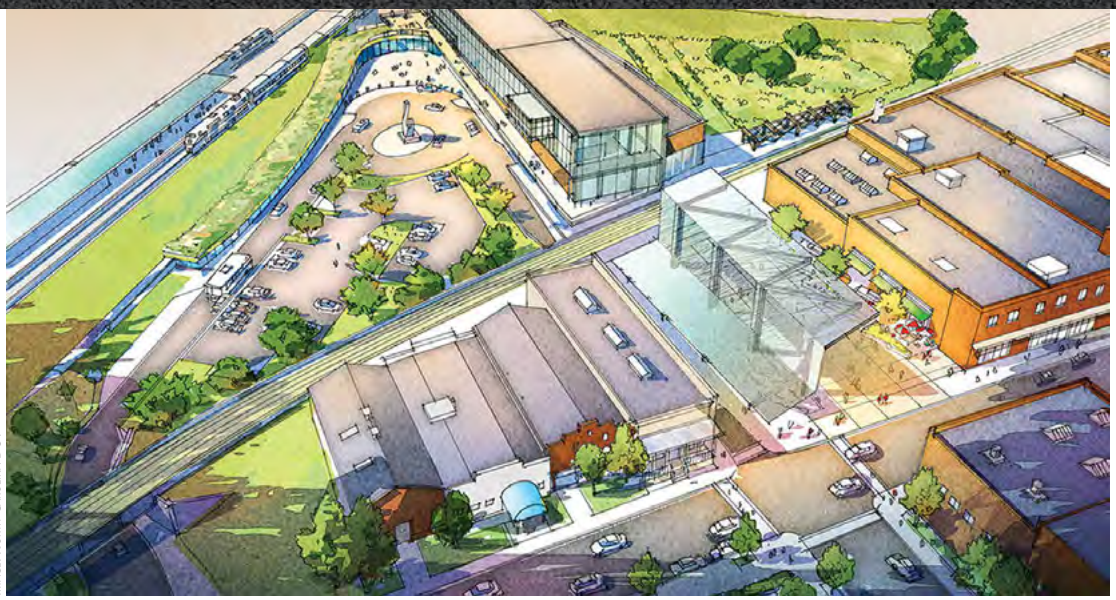


IMAGE: NORTH CAROLINA DOT

A plan for a new passenger train station in downtown Raleigh, North Carolina, has received funding from the TIGER grant program.

The Transportation Investment Generating Economic Recovery (TIGER) discretionary federal grant program allocated a fifth round of funding in 2013, providing more than $123 million dollars for infrastructure projects in 37 states. TIGER grants have totaled more than $3.6 billion dollars and have funded 270 projects in all 50 states, the District of Columbia, and Puerto Rico. U.S. DOT has received more than 5,200 applications for TIGER grants, requesting more than $114.2 billion for transportation projects.

Planning

Planners across the country have focused on the rulemaking for MAP-21, which aims to transform the transportation planning and programming processes into performance-based systems. Staff from state DOTs, metropolitan planning organizations, local transportation agencies, and transit agencies have been providing information for developing the rules, as well as detailed comments on the proposed rules. Performance goals identified in the legislation include the preservation and improvement of highways, the improvement of safety, and support for economic growth.

Many planners and programmers have not waited for federal rules to implement performance-oriented policies and practices. For example, Ohio DOT staff has explored the use of new data, such as cell phone trace data, for planning and performance monitoring.

In North Carolina, the state legislature adopted the Strategic Mobility Formula, which changes the way of selecting and funding transportation projects. The goal is to fund more transportation projects, boost the economy, and maximize the benefits of transportation spending. North Carolina DOT staff is working out the details of applying condition data, plan forecasts, and local input to prioritize projects.

These and other initiatives across the country will help transportation agencies implement the final MAP-21 rules.

Legal Issues

Risk management practices are a major legal concern in transportation agency operations, including enterprise risk management programs to identify issues in day-to-day operations and to develop cost-effective solutions. Commercial insurance products offer an economic risk management tool, particularly for so-called megaprojects and for long-term public–private partnership concessions.

States have increasingly sought legal assistance in monitoring and managing operations and in initiating related training and research projects. The effects of the *Manual on Uniform Traffic Control Devices: 2009 Edition* on state traffic and highway operations remain a concern.

New developments have emerged in the quest for more efficient environmental reviews of transportation projects. Reduced review times and simplified processes are performance goals inherent in recent actions by President Barack Obama, the Federal

In June 2013, North Carolina Governor Pat McCrory signed into law the Strategic Mobility Formula, a new way of funding infrastructure investments.

PHOTO: NORTH CAROLINA DOT

Transit Administration, and the Federal Highway Administration.

On May 17, 2013, a presidential memorandum, "Modernizing Federal Infrastructure Review and Permitting Regulations, Policies, and Procedures," directed federal agencies to work together to reduce the time to complete project environmental reviews. The memorandum increases the potential for categorically excluded projects that require little evaluation or documentation; this should speed the environmental review process.

As state DOTs increase involvement in data retention and management and prepare for the advent of automated vehicles and highways, questions arise in the following areas:

- The conceptualization of "control" in the context of automated vehicles;
- Ownership of the data required or generated by automated systems;
- The potential liability of the parties involved in the manufacture and development of automated vehicles; and
- The control of the liability exposure of the driver, the owner, and the manufacturer through private or contractual means.

Environment, Energy, and Climate Change

The lingering recovery efforts from the so-called superstorms—which include hurricanes, tornadoes, and other extreme weather events—have many states reevaluating priorities for long-term transportation infrastructure. Climate change adaptation plans adopted by states are playing an important role in decisions about long-term investments. State budgets are not increasing, and the repair or rebuilding of storm-ravaged roads and the benefits of new technologies must be analyzed.

PHOTO: PAT GAINES, FLICKR

State DOTs are developing plans for repairing infrastructure assets damaged by extreme weather events.

State legislation is influencing transportation research in California, particularly the Global Warming Solution Act of 2006, which requires state agencies to identify strategies for reducing greenhouse gas (GHG) emissions. Another bill, SB 391, requires the California Statewide Transportation Plan for 2015 to include strategies for reducing GHG emissions to 1990 levels by 2020 and to 80 percent below the 1990 levels by 2050.

Accordingly, the California Air Resources Board, California DOT, and the California Energy Commission are meeting quarterly in a unique partnership to share research proposals, projects, and other initiatives to reach the state's Climate Change and Sustainability targets. Researchers at the University of California, Berkeley, are developing a state "mitigation roadmap" for sustainable transportation, based on a comprehensive assessment of strategies for reducing GHG emissions.

Other high-visibility issues include reducing the air quality impacts of freight transportation; effects of noise on the increasing number and type of properties designated as historic; lessons from the development and deployment of environmental management systems; and innovative methods of facilitating wildlife crossings and preserving critical habitats. State DOTs are also continuing to adapt to increasingly strict regulations for stormwater management, which can affect construction costs and timelines.

PHOTO: NORTH CAROLINA DEPARTMENT OF TRANSPORTATION PHOTOGRAMMETRY UNIT

In October 2012, Superstorm Sandy washed out parts of NC-12 in Pea Island Wildlife Refuge in North Carolina. Many states are incorporating the potential effects of intense storms into their long-term infrastructure plans.

Photo: Elissa Jun, Federal Emergency Management Agency

A downed power line in Prattsville, New York, after Hurricane Irene in 2011. States are studying the connection between transportation infrastructure and other networks, such as the power grid.

Critical Infrastructure Protection and Security

In the aftermath of Superstorm Sandy and other extreme weather events, states have increased focus on system resilience and on understanding the interrelationships between transportation infrastructure and other major lifeline systems, such as the power grid, fuel supply chains, and water systems. The cascading failures of these systems during Superstorm Sandy affected the region's ability to recover within a reasonable time. In New York and New Jersey, filling stations faced two major problems: inadequate fuel, because of limited prepositioned supplies, and power outages.

In collaboration with the Regional Resiliency Assessment Program of the U.S. Department of Homeland Security (DHS), New Jersey is examining the interdependencies in the state's petroleum distribution system, applying the lessons learned from Superstorm Sandy. The state has instituted the Retail Fuel Station Energy Resiliency Program, which includes grants to help retail fuel stations along key routes purchase generators and "quick connects" to power the pumps.

In May 2013, DHS issued an update to the National Response Framework that "mandates the development of a series of policy and planning documents to explain and guide the nation's collective approach to ensuring and enhancing national preparedness." Working with the American Association of State Highway and Transportation Officials (AASHTO), states are prioritizing support for the implementation of the National Response Framework, the National Incident Management System, and the National Infrastructure Protection Plan.

Data and Information Technologies

States are developing data approaches to support enterprise management initiatives, such as performance management and asset management. Constrained resources, however, have focused data efforts

Photo: Brian Kingsley, Flickr

Residents of Queens, New York, stand in line for gas. New York and New Jersey experienced fuel shortages and fuel station power outages after Superstorm Sandy.

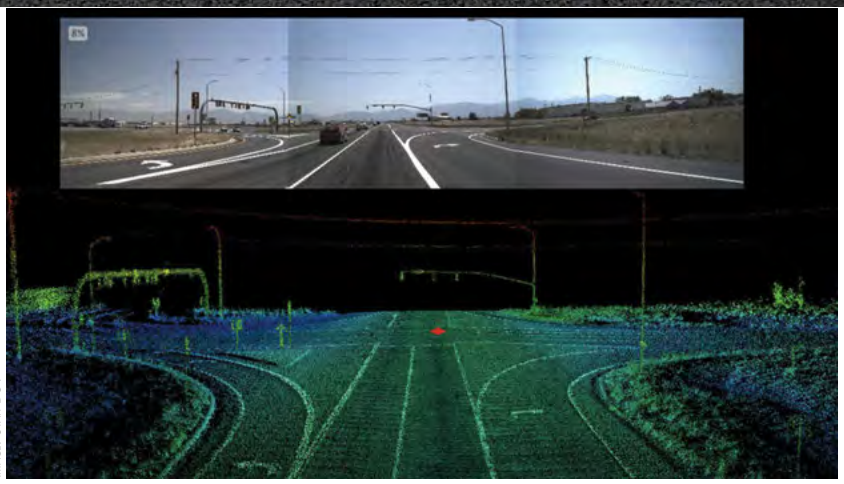


Image: Utah DOT

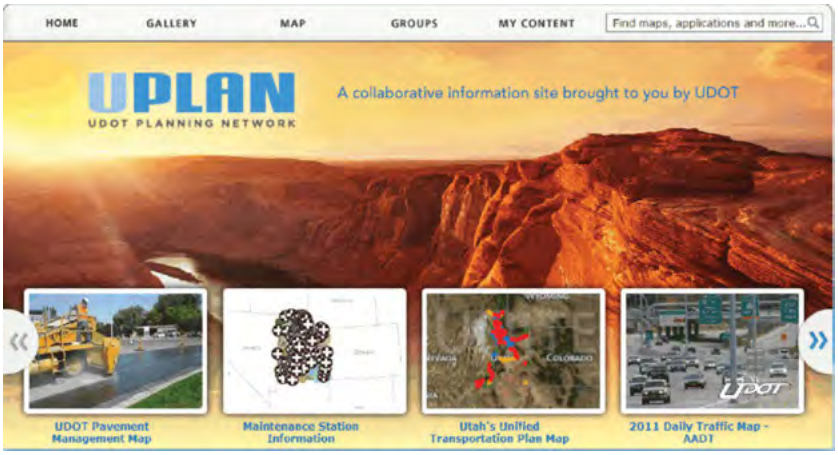
A Utah DOT project uses mobile lidar to map the state's roadway assets.

on providing information for decision making, often to explore the trade-offs between maintenance and capital expenditures, among links, and between modes. The Maryland State Highway Administration uses improvement to the entire transportation system as a criterion. TRB's National Cooperative Highway Research Program (NCHRP) is developing tools to improve the use of data for investment decisions, both for intermodal trade-offs and for identifying and prioritizing areas for improvement.[4]

Spatial location has proved to be a valuable tool for interrelating information from different sources. Utah DOT's UPlan is a spatial framework that can array data from different programs and from other agencies in the state. An AASHTO Technology Implementation Group is helping other states pursue this model. Iowa DOT has made spatial location a facet of all information sources.

Working under funding constraints for data programs, states are using technology and partnerships to improve the quality and availability of information. Wyoming DOT has implemented a cooperative program with the National Park Service for traffic counts in and around Yellowstone National Park.

[4] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2725; http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3399.



Utah DOT's mapping and planning tool UPlan allows data sharing among units and assemblies and disseminates roadway information in a user-friendly environment (http://uplan.maps.arcgis.com).

Improved understanding and communication of the transportation system's role in supporting the state economy and businesses is gaining importance as officials make the case for the needed investments. For businesses, understanding freight flows and supply chains is key; the U.S. DOT Freight Analysis Framework, which uses data from the Commodity Flow Survey of the Bureau of Transportation Statistics, provides a foundation for business freight planning.

Aviation

Government funding issues continue to affect the national aviation system. Budget cuts resulting from the sequestration temporarily forced the closure of more than 100 air traffic control towers at smaller airports; the staff limitations and the reduced staff hours for air traffic controllers caused major delays at larger airports and throughout the aviation system. Although the restrictions were temporarily over-

Photo: The Columbus Dispatch

Federal budget cuts in 2013 forced the closures of air traffic control towers at smaller airports, such as Don Scott Field at Ohio State University in Columbus.

turned, the ongoing uncertainty about the budget makes the system susceptible to costly failures and delays and slows the implementation of much-needed system improvements through the NextGen program.

The airline consolidation trend proceeded with the merger of American Airlines with U.S. Airways. Objections raised by the U.S. Department of Justice only delayed what many considered inevitable; nevertheless, some concerns continue about the impacts on consumers from ticket prices and in the availability of flights to and from less-served airports.

Other issues at the forefront include the incorporation of unmanned aircraft into U.S. civilian airspace; new safety-related rules changing the flight-hour requirements for pilots to fly commercially and the effects this may have on the availability of qualified pilots; new technologies that enable more extensive use of alternative fuels in commercial aircraft; and how the collection and analysis of big data—large and complex data sets—may change aviation.

Photo: Kelly Martin, Flickr

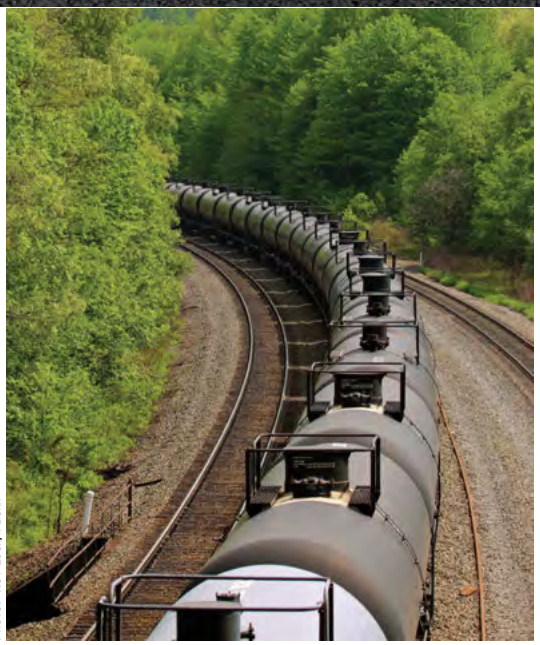


Photo: Roy Luck, Flickr

(*Far left:*) The U.S. DOT's initial Primary Freight Network includes I-70—which runs from Maryland to Utah—and other major Interstates.

(*Left:*) Empty oil tanks travel from East Coast refineries to North Dakota, which has seen a large increase in oil- and gas-related freight transportation.

Freight Systems

In implementing the freight provisions of MAP-21 for the rulemaking due this year, U.S. DOT and states are working to define performance measures for freight movement on the Interstate Highway System. U.S. DOT has drafted an initial designation of the Primary Freight Network and has established a National Freight Advisory Committee of public officials, private-sector stakeholders, and academicians, including several TRB leaders. State DOTs are adopting freight plans and establishing advisory committees to be eligible for higher federal funding matches for freight-related highway projects.

Dramatic increases in freight transportation related to oil and gas hydraulic fracturing operations have presented challenges in North Dakota, Texas, New York, West Virginia, Louisiana, and other states. In many cases, oversize trucks carrying heavy equipment, as well as the inputs and outputs from the operations, are causing problems for road maintenance and safety on two-lane, low-volume roads not engineered for heavy truck traffic.

The domestic energy boom also affects freight rail, particularly with increases in mile-long unit trains carrying the fracturing sand and petroleum. In rural areas, a passing wall of tanker cars along an at-grade rail crossing effectively can cut a small town in half and can create issues for emergency management and residents' mobility.

Highway Design

To improve highway performance, designs are applying pavement and bridge management data, information from bridge monitoring systems, and procedural innovations. Florida DOT, for example, is examining management system data to determine if infrastructure performance is consistent, predictable, and repeatable. When a performance rating is lower than expected, the agency uses the data to improve the designs.

Connecticut DOT is incorporating creative, research-based solutions into designs. To extend bridge performance, the agency is implementing damping systems to reduce fatigue damage. Nationwide, similar efforts are under way to improve the design of accelerated bridge construction projects, including seismic connections—such as sacrificial structural fuses—to mitigate damage.

Minnesota DOT has heavily instrumented the I-35 West–St. Anthony Falls Bridge to monitor time-dependent behavior, such as shrinkage and creep. Although the posttensioned, precast concrete box-girder bridge is only five years old, the department has collected a significant amount of data on concrete behavior, enabling better prediction of long-term per-

States use data from bridge monitoring systems for performance management of repairs and construction.

Photo: Wikimedia Commons

Photo: Joe Bielawa, Wikimedia Commons

The new I-35 West–St. Anthony Falls Bridge in Minnesota has more than 300 sensors that monitor bridge conditions.

formance. The agency's bridge designers are applying the information to improve concrete bridge plans.

Many state DOTs are cooperating in pooled-fund studies of design-related performance, to spur innovation and address uncertainties. Through statistical and probabilistic analyses, several studies are developing more accurate design methodologies to improve performance and maximize return on investment.

Highway Construction and Materials

State transportation agencies are working to deliver high-quality highway infrastructure projects faster and at less cost. Many are completing larger projects under any one of a variety of alternative project delivery systems. Construction manager-at-risk is a newcomer to the toolbox; an NCHRP project has prepared a guidebook.[5] States recognize the need for alternative quality management systems for these project delivery approaches. Another NCHRP project is identifying the systems and developing guidelines.[6]

State agencies have been emphasizing sustainability and recycling. Many are open to using recycled waste materials or by-products in highway construction, as long as the materials are evaluated in the same way as virgin or traditional construction materials, for structural integrity, cost, and environmental implications. Reclaimed asphalt pavement (RAP) is now common in most states, and the use of reclaimed asphalt shingles (RAS) is on the rise. Some states have applied asphalt mixtures with up to 35 percent RAP; others allow RAP–RAS mixtures.

Cold-recycling technology is gaining attention. An NCHRP project is exploring cold in-place recycling and full-depth replacement.[7] Virginia and Maryland have used slag cement as a sustainable material, and others have indicated interest. Two-lift concrete paving construction promotes recycling but limits the higher-quality materials to the upper lift. The Illinois State Toll Highway Authority has used the technique on an Interstate 90 project.

[5] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2963.
[6] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2714.
[7] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2530.

Photo by Brian K. Diefenderfer, Virginia Center for Transportation Innovation and Research

Material is stabilized with lime kiln dust in an in-place recycling project on I-81 in Virginia. Many states have adopted the use of reclaimed asphalt in construction projects.

Geotechnical Engineering

Emerging issues and concerns of geotechnical engineering practitioners in the public and private sectors include the following:

◆ Critical projects are requiring large amounts of geotechnical and construction data, raising concerns about how to collect, compile, process, and interpret these data efficiently.

◆ The use of geotechnical engineering instrumentation before and during construction has helped verify design criteria and soil and rock properties. This approach has reduced costs and risk; disseminating information about the new techniques is important.

◆ Soil and aggregate are compacted to increase the density of embankments and pavements and improve performance. To measure density, most states use the nuclear density gauge (NDG), which has high operating costs and raises safety concerns—the device contains radioactive material. States therefore are exploring nonradioactive devices as an alternative to NDG. An NCHRP Synthesis project is expected to provide useful information on nonnuclear devices for practitioners and researchers.[8]

◆ States are considering the reuse of foundations in bridge rehabilitation to reduce project costs, construction delays, environmental impacts, and traffic congestion. States are developing guidelines and methodologies for the approach.

[8] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3362.

Photo: Minnesota DOT

Geotechnical engineering instrumentation can help lower costs and risks associated with construction projects.

In Kansas, the Mission Gateway Project, a design–build megaproject, is riddled with old underground limestone mines. Kansas DOT's geotechnical engineering unit prepared a three-dimensional digital model for contractors interested in submitting bids—a first for a U.S. design–build project.

Highway Operations

Agencies are exploring a range of newer intersection and interchange configurations that have improved traffic operations and reduced crashes. These include diverging diamond interchanges, continuous-flow intersections, superstreets, Michigan lefts, and J-turns.

Photo: Missouri DOT

A school bus enters a J-turn on US-65, south of Buffalo, Missouri. New configurations can lead to safer intersections and better traffic flow.

Photo: TruckPR

Many commercial vehicle-to-infrastructure technologies already are on the market, including the Drivewyze system that provides weigh-station bypasses for truck drivers.

Proactively managing and operating the roadway cross section is becoming commonplace in many states. Agencies are attempting to optimize use of the entire roadway to improve the performance of specific lanes or of the entire freeway or highway. Under the active traffic management approach, the operating agency proactively manages demand and available capacity on a facility by applying operational countermeasures or modifying strategies.

Active traffic management strategies include dynamic speed limits, restricted lanes allowing only high-occupancy vehicles or trucks, access controls such as express or reversible lanes, motorist information such as electronic dynamic message signs and lane control signs, peak-hour shoulder use, ramp metering, and priced and managed lanes. These solutions have proved cost-effective in reducing delay and improving travel-time reliability.

Vehicle-to-vehicle and vehicle-to-roadway technologies, along with road vehicle automation, are anticipated to be the next major breakthroughs in operations and safety. Federal and state agencies, the automobile industry, and other private-sector partners have been researching the effectiveness and feasibility of advanced vehicle technology. Deployment could fundamentally change the way people drive, advance real-time operations, and prevent crashes.

Many industry and academic experts predict limited automated driving as early as 2015, with fully automated vehicles by 2020. To prepare the way, a few states have enacted legislation allowing the operation of automated vehicles on their roadways, and other states are contemplating similar legislation.

Infrastructure Preservation

In preparation for the maintenance-related performance measures for pavement and bridge assets under MAP-21, many agencies are updating their maintenance management systems. Some, like Tennessee DOT, are determining which activities are better suited for the agency to handle and which for a contractor. The justification now relies less on agency perceptions and more on data from maintenance management systems.

State DOTs are applying preservation principles in managing infrastructure. States recognize the importance of preserving and maintaining not only their infrastructure but also their equipment fleets, a significant operational expenditure. Savings in the operational costs of fleet equipment can have an impact on an agency's ability to deliver its program. Okla-

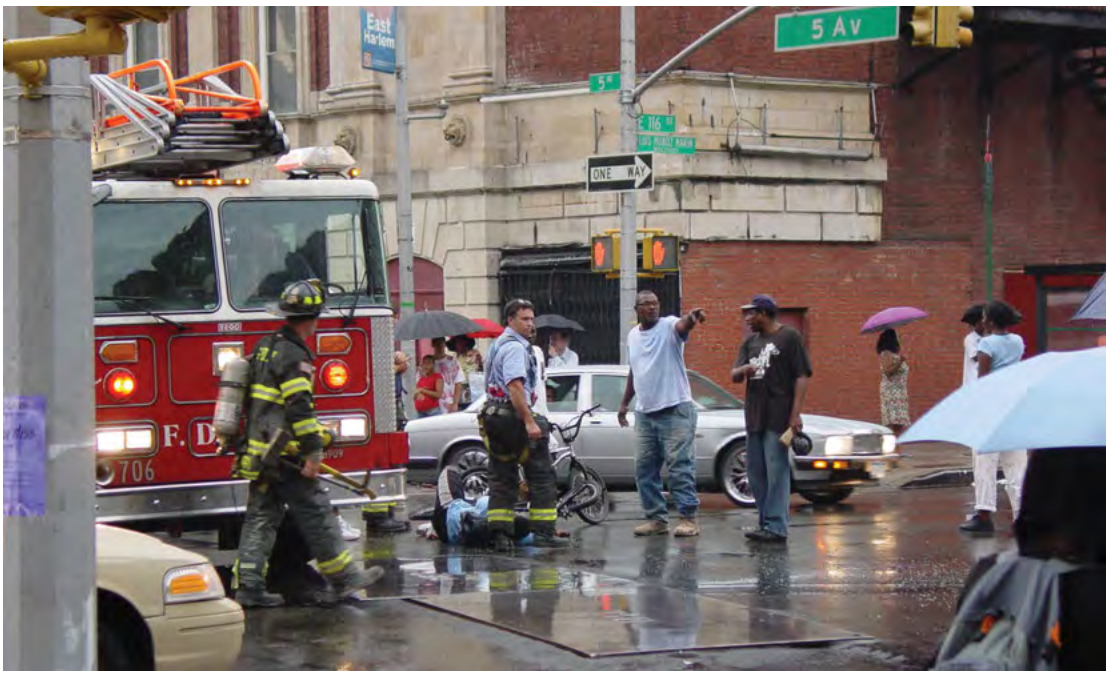
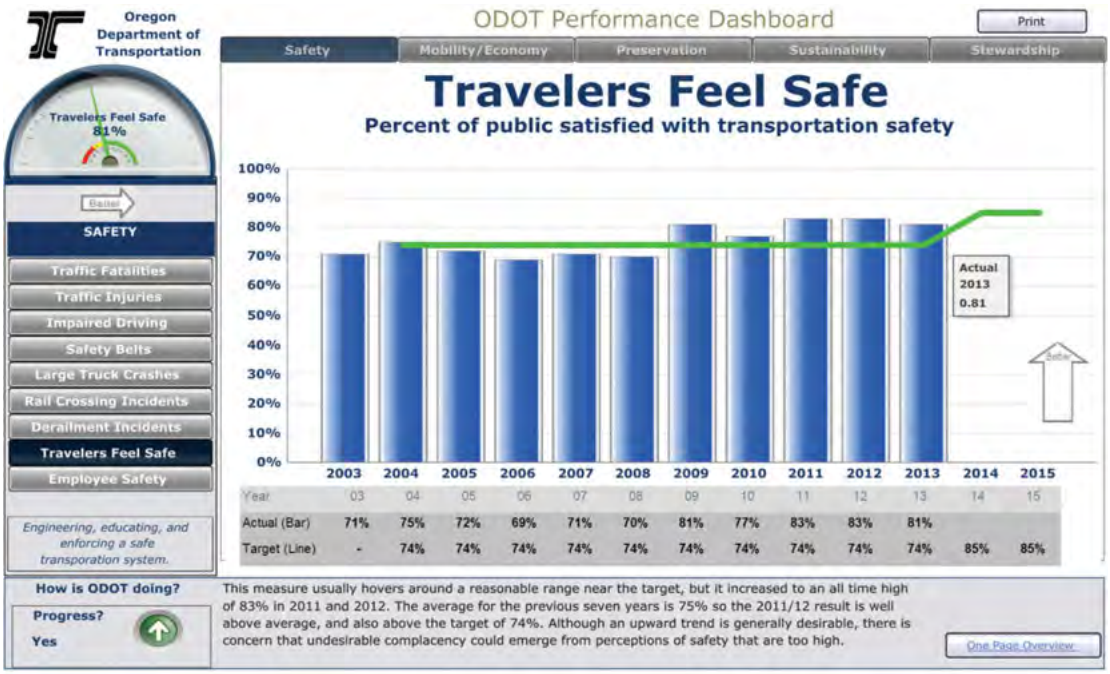


Photo: Rob Boudon, Flickr

Some states have experienced increases in bicycle- and pedestrian-related crashes.



Oregon DOT's Performance Dashboard website reviews the safety of its travelers, roads, rail systems, and employees.

homa DOT, for example, is converting its fleet to compressed natural gas; the estimated annual savings with full implementation will be $3 million.

Highway Safety

In 2012, 33,561 people lost their lives in motor vehicle crashes in the United States, according to the National Highway Traffic Safety Administration (NHTSA). Although this increase after six years of declining fatalities does not constitute a trend, it demonstrates the complexity of highway safety.

Decision makers are trying to understand how various factors have affected highway fatality trends, to invest limited resources most efficiently in programs with the greatest potential for reducing fatalities and serious injuries. Increased safety belt use, safer vehicles, better roads, increased funding for infrastructure improvements, the economic downturn, changes in teen licensing laws, and enhanced enforcement efforts are among the factors identified as possible contributors to the downward trend in crashes.

The recent increases in fatalities appear to be associated with a variety of crash characteristics. The rise in pedestrian and bicyclist fatalities and injuries has raised concern in several states. Massachusetts now conducts road safety audits after most pedestrian- or bicycle-related fatalities to understand the nature of the crash and to explore the measures necessary to prevent similar crashes.

MAP-21 requires states to focus on safety performance targets, especially involving fatalities and serious injuries. Oregon DOT has developed a Performance Dashboard Website, which posts gauges, graphs, trend symbols, and text to summarize progress in the state toward various targets, including safety indicators.[9]

Ports and Waterways

After the major system disruptions caused by weather-related events in 2012, including Superstorm Sandy on the East Coast and drought conditions in the Midwest, states and their federal agency partners with stewardship over ports and waterways have been examining the resilience of the marine

[9] www.oregon.gov/ODOT/CS/PERFORMANCE/docs/2014%20Dashboard.swf.

Workers repair the dewatered Algiers Lock in New Orleans, Louisiana. Locks closed for repairs cause delays for cargo on the network.

Photo: U.S. Army Corps of Engineers

Did You Know?

- Wyoming has more "blow off the road" crash locations than any other state. Wyoming DOT posts a "No Light Trailer" message on information systems when wind gusts exceed 50 mph under any road conditions. In locations with wind gusts of 65 mph or more and with adequate signage, Wyoming DOT will initiate closure to light, high-profile vehicles. The closure targets vehicles that are prone to being blown over, such as recreational vehicles, moving vans, and lightly loaded commercial vehicles; the restriction also includes smaller vehicles pulling trailers.
- Wyoming has a population of nearly 600,000 in nearly 100,000 square miles; officials describe their state as "one community with very long streets."
- Bicycle traffic is increasing by 4.6 percent per year in Minneapolis, Minnesota, according to a planning model developed in research on the city's bicycle and pedestrian traffic.
- In December 2013, Michigan became the fourth state to pass legislation that allows the testing of automated vehicles on public roadways. The law requires a human in the driver's seat at all times to monitor performance and take control if necessary. Other states that have passed similar laws include Nevada, in 2011, and Florida and California, in 2012.

PHOTO: WYOMING DOT

On days with high winds, Wyoming DOT closes roads to vehicles prone to being blown over.

PHOTO: FRANCES BENJAMIN JOHNSTON COLLECTION, LIBRARY OF CONGRESS

An automobile outside a garage in Greenwich, Connecticut, in 1908. The state had established the nation's first speed limit only 7 years earlier.

- The average number of deer–vehicle collisions in Virginia approaches 50,000 a year, the fifth highest in the United States. Virginia DOT spends approximately $4 million annually to remove animal carcasses from the road for proper disposal in landfills. A recent study by the Virginia Center for Transportation Innovation and Research shows that Virginia DOT could save $0.5 million by windrow composting the deer carcasses.
- In 1901, to get speeders under control and make the roadways safer, Connecticut passed the nation's first speed limit: 12 mph.
- Road dust is the leading source of particulate matter in Montana. Of the state's 14 areas designated by the Environmental Protection Agency for nonattainment of air quality standards, 10 were cited for high levels of particulate matter.
- Belle Fourche, South Dakota, is the site of the geographic center of the 50 United States of America.
- In 2012, Minnesota DOT's Library Services provided a return on investment—in time saved in dollars and in actual dollars saved—of $1.90 for each $1 the agency spent on library staff and materials.
- Union Pacific's rail switch yard in western Nebraska is the largest in the country, according to Nebraska Department of Roads and the University of Nebraska.

PHOTO: SIEMENS

The new Amtrak Cities Sprinter high-speed electric locomotive undergoes tests at the U.S. DOT Transportation Technology Center in Pueblo, Colorado, in 2013.

transportation system. The concern for resiliency extends beyond natural events to the aging and inadequate infrastructure, which continues to cause delays and increase costs across the supply chain—for example, when locks on the inland waterways are taken offline for repairs, or when cargo vessels must light-load because navigation channels are not dredged to their federally authorized dimensions.

These issues have created unprecedented momentum for passage of the Water Resources Development Act, which authorizes the navigation and waterways infrastructure programs under the U.S. Army Corps of Engineers. Bringing waterways infrastructure up to a state of good repair and prioritizing expansion projects in a fiscally constrained environment are priorities for states that rely on seaports and the inland waterways system for economic prosperity and jobs. In August, the Kentucky Transportation Center at the University of Kentucky held a symposium in Louisville to discuss the movement of freight via the nation's inland waterways and connecting rail systems.

With the Panama Canal expansion scheduled for completion in 2015, larger vessels will be able to transit the canal and call on U.S. East and Gulf Coast ports. States continue to invest in their seaports and landside intermodal infrastructure to prepare for these cargo opportunities.

Rail

Passenger Rail

The Passenger Rail Investment and Improvement Act of 2008 requires that states share passenger train operating costs with Amtrak for routes of less than 750 miles; the Northeast Corridor, however, is exempt. The act mandated cost-sharing agreements between Amtrak and the various states by October 1, 2013, and negotiations between Amtrak and the states were successfully completed without any loss of service. Amtrak continues to cover the costs of its long-distance trains and of trains in the Northeast Corridor.

In other passenger rail developments, planning for the California high-speed rail system continued despite efforts to halt the project because of environmental and fiscal concerns. Amtrak set new ridership records in the past year and began taking delivery of new high-speed electric locomotives for the Northeast Corridor.

Freight Rail

Changes in the energy production industry had a profound effect on freight rail in 2013. Sustained growth in well development increased rail traffic in drilling equipment and fracturing sand, but the most notable trend was the continued growth in the movement of crude oil by rail. A disastrous derailment and

PHOTO: SÛRETÉ DU QUÉBEC VIA TWITTER

The June 2013 freight train derailment in Lac-Megantic, Quebec, was one of the deadliest rail accidents in Canadian history.

According to a recent survey by the American Public Transportation Association, the younger generation of travelers is embracing alternatives to automobile travel—and many value mobile phone ownership above car ownership.

PHOTO: PEDESTRIAN AND BICYCLE INFORMATION CENTER

explosion in Canada has raised questions about safety. Repercussions and findings from the investigation of the accident will continue to affect the North American rail freight industry.

Public Transportation

Vehicle miles of travel continue to level off in the United States; automobile ownership is declining, while ridership on all modes of public transportation has grown by 16 percent since 2000. The following trends and advances present opportunities and challenges for the transit industry:

◆ **Demographics.** The American Public Transportation Association's comprehensive survey of "new millennials"—persons born between 1982 and 2003—indicates a shift in attitudes about automobile ownership and willingness to walk, bike, ride transit, or carpool when the choice is cost-effective and convenient. The survey indicates that this population values mobile phones more than automobiles as a personal possession.

◆ **Data and communications technology.** The creation and implementation of the General Transit Feed Specification provide transit customers with web- and smart phone–accessible information about schedules and service navigation. Cities from San Francisco to Denver, New York, and Boston have mobile apps in place to help users navigate multimodal transit networks.

◆ **New services in urbanized areas.** Cities from Toronto, Ontario, to Washington, D.C., are hosting carsharing and bikesharing services, making door-to-door trips more convenient and inviting for transit riders and reducing congestion and the demand for parking in densely developed urban areas.

◆ **Policy focus.** Superstorm Sandy, high-profile accidents on commuter and subway trains, and MAP-21 are drawing policy attention to practical issues of safety, resilience, state of good repair, and performance measures for transit.

Chicago, Illinois, opened its first bikeshare station in June 2013.

PHOTO: ROBIN AMER, WBEZ

Enhancing System Performance

TRB salutes the transportation organizations, leaders, and innovators who—as the examples above demonstrate—are working to enhance the performance of transportation systems and services. TRB will continue to provide research and disseminate information on performance management and related areas across its programs and activities. More information on TRB resources in this area—including publications, committees, events, and webinars—is available on the TRB Performance Measurement Information Resource Center at www.TRB.org/ABC30/ABC30.aspx.

Innovative Bridge Designs for Rapid Renewal

SHRP 2 Project Develops and Demonstrates a Toolkit

BALA SIVAKUMAR

Bridge deterioration and the need for bridge replacements are problems throughout the United States. Accelerated bridge construction (ABC) techniques can minimize traffic disruptions during bridge renewals, promote traffic and worker safety, and improve the quality and durability of bridges.

Agencies have applied ABC to emergency and to planned bridge replacement projects. Although most agencies are aware of ABC, few practice the techniques routinely. The second Strategic Highway Research Program (SHRP 2) created Project R04: Innovative Bridge Designs for Rapid Renewal to develop technical solutions to promote and facilitate ABC.[1]

ABC applications in the United States have developed two approaches:

- In-place construction with prefabricated bridge elements and systems (PBES) and
- Placement of bridges preassembled at an off-alignment location and moved into final position with special technology and equipment.

Rapid construction of bridges in place offers limited closures that last only days or weeks at the most. Preassembled bridges are an alternative, moved into place with a variety of techniques including lateral sliding, rolling, and skidding; incremental launching; and self-propelled modular transporters.

Stimulating Adoption

Focus group meetings with representatives from more than 20 state departments of transportation (DOTs) identified several reasons for the slow adoption of ABC. Despite the eventual lower costs and the life-cycle cost savings, the higher initial cost of implementing an ABC program has hampered widespread and sustained implementation. Utah DOT's ABC program, however, has demonstrated that with sufficient and repeated application, precast bridge components can become more economical and construction more efficient.

[1] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2167.

The author is Vice President, HNTB, New York, New York.

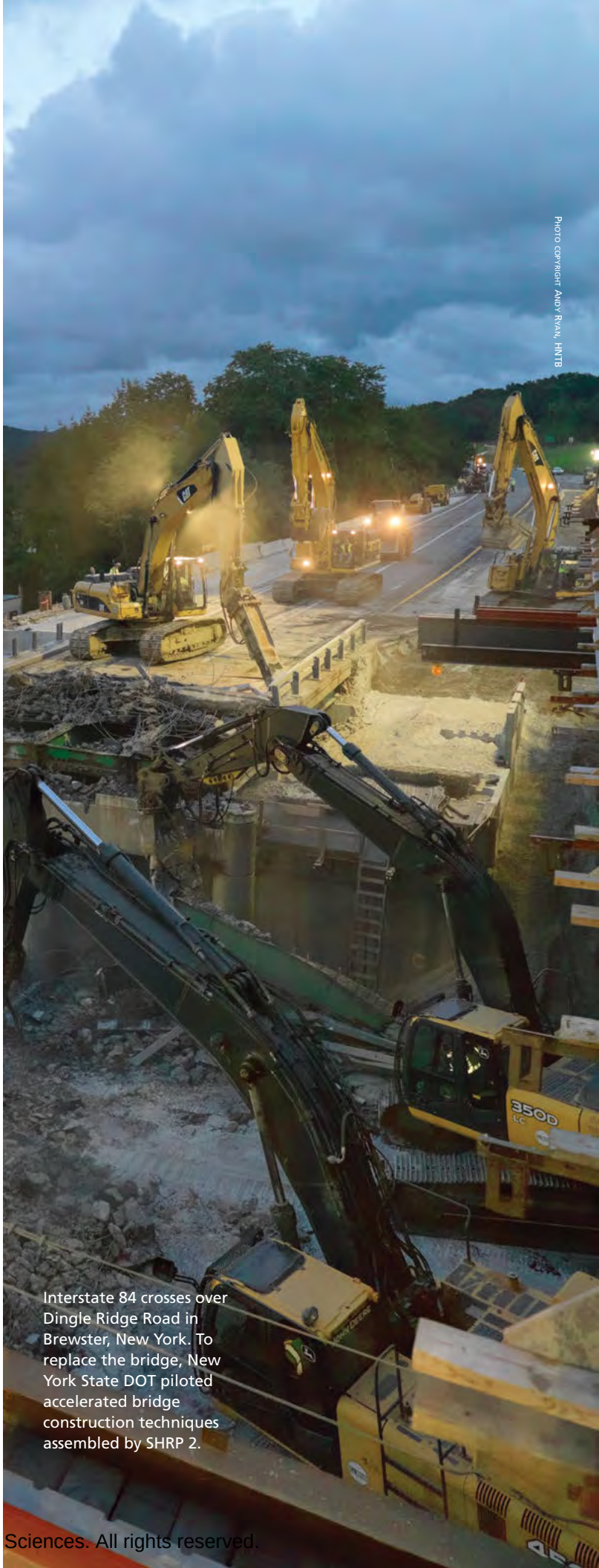


Photo copyright Andy Ryan, HNTB

Interstate 84 crosses over Dingle Ridge Road in Brewster, New York. To replace the bridge, New York State DOT piloted accelerated bridge construction techniques assembled by SHRP 2.

PHOTO: IOWA DOT

The replacement of the US-6 bridge over Keg Creek in Council Bluffs, Iowa, was the first project to use the SHRP 2 ABC Toolkit.

ABC is also generally perceived as raising the level of risk associated with a project. Designers therefore are reluctant to suggest the approach; many procurement methods do not offer incentives for creativity. Alternative contracting mechanisms, such as "best value" awards, can allow engineers and contractors to team together, present their best ideas, and introduce innovative designs and construction technologies into projects.

Finally, local contractors prefer cast-in-place construction for bridge renewals. Contractors have noted that large precast elements diminish profitability. Moreover, ABC involves a new technology, and contractors prefer to keep their own employees working instead of subcontracting work to precasters. The solution is to introduce the industry to precast technology and to demonstrate profitability.

Modular Solutions

The custom engineering of every solution has been another major impediment to the adoption of ABC. Instead, pre-engineered modular systems configured for traditional construction equipment could reduce costs. Modular bridge systems that can be built with conventional construction equipment also enable local contractors to bid on rapid replacement projects.

Repetition makes precast components more economical and construction faster and more efficient. Building this capability, however, requires working with local contractors over several projects—rapid bridge replacements must become commonplace. Agencies could bundle several bridge sites with similar requirements into a single construction contract.

The potential weak link in prefabricated systems traditionally has been the connections between components—for example, the closure joint between deck panels, column to cap, or the drilled shaft of the footing to the column. Although the prefabricated components are constructed in controlled environments, the closure joint is exposed to the variability of field construction.

Transverse and longitudinal deck closure joints are the biggest challenge to long-term, minimum-maintenance durability and to rideability and smoothness. Recent advances in high-performance materials have introduced a new generation of connections that are more durable, low in maintenance, and rapidly completed.

Investigations have shown that full-moment connection with ultrahigh-performance concrete (UHPC) satisfies the criteria for constructability, structural behavior, and durability in modular superstructure systems. UHPC facilitates small-width, full-depth closure pour connections between the modular components.

SHRP 2 ABC Goals

The SHRP 2 exploration of ABC practices has shown that owners, designers, and contractors innovating incrementally and collaboratively can meet the challenges of implementation. Owners have found that ABC experience leads to contractor acceptance as well as to savings in schedules and costs. As noted, the initial additional costs diminish with consistent and repeated use of the ABC approach.

Launched in 2007, SHRP 2 Project R04 sought to develop standardized design approaches and to construct complete bridge systems under renewal with minimal disruptions to traffic. ABC entails prefabricating as many of the bridge components as feasible. For efficiency, ABC designs should allow maximum opportunities for the general contractor to handle the prefabrication and erection; contractors often are reluctant to outsource their work.

The SHRP 2 project team focused on strategies for developing ABC solutions that were

- As light as possible,
- As simple as possible, and
- As simple-to-erect as possible.

To facilitate precasting by the contractor, the design of the components should

- Be simple enough to fabricate,
- Allow some tolerance for erection,
- Reduce formwork cost by maximizing repetition, and
- Be erected with conventional equipment, such as cranes.

Ideally the infrastructure would be renewed without interruptions to traffic or services. Although this may not be possible, the owner and contractor should identify systems that balance the demands of budget and schedule to meet the objectives of the project.

Using complete prefabricated bridge systems, including foundations and substructures, maximizes construction speed onsite. The foundation and substructure are often the most costly and time-consuming parts of bridge construction. The SHRP 2 project has provided ABC design concepts for complete prefabricated bridge systems, including the superstructure and substructure, as well as strategies for shallow and deep foundations.

Project Phases

SHRP 2 Project R04 followed four distinct phases from 2007 to 2013. Phase 1 collected data on ABC projects and identified the impediments and challenges to ABC. Through screening and evaluations, the work in Phase 2 winnowed down the findings and ABC concepts collected in Phase 1. The process evaluated the engineering and constructability of the concepts and identified the obstacles to implementation.

Phase 2 proposed a short list of concepts that could advance to recommended design standards and to implementation. Standard concept plans were developed for the most useful technologies deployable on a large scale in bridge replacements. The standard concepts, plans, design examples, and recommended specifications were organized into the SHRP 2 *Innovative Bridge Designs for Rapid Renewal: ABC Toolkit*, a single document for bridge engineers.[2]

In Phases 3 and 4, two pilot projects were selected to showcase the ABC technologies and design concepts. The first pilot, completed in 2011, used prefabricated elements to accelerate construction; the road closure was reduced to two weeks. The second pilot, built in late 2013, applied the lateral slide method of overnight bridge replacement; the road closures were reduced to one night for each of two overpass bridges.

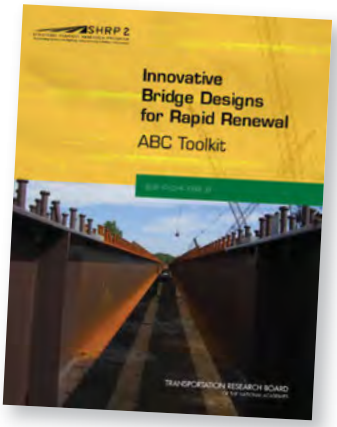
SHRP 2 ABC Toolkit

Pre-engineered standards are commonplace in bridge engineering. To make the best use of program dollars, many states standardize designs through pre-engineered systems and plans; these can encompass entire bridge systems. The guideline drawings can reduce engineering calculations and details and can apply to different site conditions. The use of pre-engineered bridge systems can reduce costs with in-place construction and can improve quality.

Although it provides design and construction concepts for complete bridges, the SHRP 2 ABC Toolkit is not intended as a comprehensive manual on ABC or PBES but as a complementary resource. The toolkit focuses on the design and assembly of routine bridges with ABC techniques that would be of value to engineers, owners, and contractors new to ABC.

Standardized designs for conventional crane-based erection incorporate repetitive use of modular superstructure systems. Repetitive use allows contractors to amortize equipment costs over several projects, bringing total costs in line with cast-in-place construction. When site conditions make crane-based erection difficult, overhead erection with ABC technologies offers an attractive alternative. The standard concepts in the toolkit address both options.

A single set of ABC designs for national use would not be practical because of the state-specific modifications in the American Association of State Highway and Transportation Officials' (AASHTO's) *LRFD Bridge Design Specifications*.[3] The ABC toolkit, however, includes a set of standard concepts for design and construction.



SHRP 2 Report S2-R04-RR-2, *Innovative Bridge Designs for Rapid Renewal: ABC Toolkit*, can be accessed via www.trb.org/Main/Blurbs/168046.aspx.

[2] www.trb.org/Main/Blurbs/168046.aspx.

[3] LRFD = load and resistance factor design; specifications for the design, evaluation, and rehabilitation of bridges, based on statistical knowledge of loads and structural performance.

PHOTO: IOWA DOT

Accelerated systems and techniques include precast modular abutment systems, precast complete pier systems, modular superstructure systems, and bridge erection systems.

ABC Design

Guided by the standard concepts and details, and consulting the ABC sample design calculations, the engineer of record (EOR) should be able to complete an ABC design for a routine bridge replacement project. The EOR will need to customize the standard concepts to fit the specific site's bridge geometry, span configuration, member sizes, and foundations.

The configurations of the modules, their assembly, connection details, tolerances, and finishing would remain unchanged from site to site. The ABC designs should be reviewed for compliance with state-specific LRFD criteria.

The toolkit includes typical ABC details for the superstructures and substructures of routine bridges suitable for a range of spans. The standard concepts provide substantially complete details. Much of the remaining work in preparing design plans is not particularly ABC-related but addresses bridge- and site-specific customization.

ABC Concepts

General information sheets, plan notes, and instructions cover key design and construction issues in ABC projects. In conjunction with the ABC sample design calculations and design specifications, the standard concepts assist designers in becoming knowledgeable about ABC.

The standard concepts in the ABC Toolkit include the following complete prefabricated elements for modular bridges and construction technologies:

- Precast modular abutment systems: integral abutments, semi-integral abutments, and precast approach slabs;
- Precast complete pier systems: conventional pier bents and straddle pier bents;
- Modular superstructure systems: decked steel stringer system, concrete deck bulb tees, and concrete deck double tees; and
- ABC bridge erection systems: erection using cranes, above-deck driven carriers, and launched temporary truss bridges.

Design Considerations

The design considerations for the ABC standard concepts for modular systems developed in the SHRP 2 project are as follows:

- Substructure modules that have dimensions and weights suitable for highway transportation and erection with conventional equipment;
- Substructure modules that can accommodate deep or shallow foundations according to site requirements;
- ABC designs and specifications that allow the contractor to prefabricate the nonprestressed components;
- Prefabricated modules designed for quick assembly in the field with full-moment connections, as well as joint details that allow rapid assembly in the field;
- Modules for simple spans and continuous spans with details that eliminate deck joints at piers and abutments;
- Accommodation for moderate skews—although eliminating skews altogether and making the spans slightly longer and square would be more beneficial for rapid renewal;
- Use of high-performance materials: high-per-

formance concrete or UHPC, and high-performance steel or A588 weathering steel;

◆ Segmental installation without cross frames or diaphragms between adjacent segments, improving the speed of construction and reducing costs—although diaphragms remain an option;

◆ Control of camber for longer spans in modular superstructures—controlling the fabrication of concrete sections, the time to erection, and the curing procedures to minimize the camber differences between adjacent deck sections;

◆ An integral wearing surface in lieu of a field-applied overlay, to expedite construction; and

◆ Prefabricated approach slabs, to expedite the approach work, and methods such as flooded backfill, to reduce time for backfilling operations.

The typical designs for superstructure and substructure modules address three ranges of spans: 40 to 70 feet, 70 to 100 feet, and 100 to 130 feet.

Connecting Units

Connections of the modular units in ABC determine how easily the elements can be assembled and connected to form the bridge system. Often the time to develop a structural connection depends on the cure times for the closure pour.

The number of joints and the type of joint detail are critical to the speed of construction and to the durability and long-term maintenance of the structure. ABC minimizes the use of cast-in-place closure joints. Although the ABC Toolkit focuses on innovative materials such as UHPC for connections, post-tensioning is an established alternative described in other sources.

The detailed sample design calculations provide step-by-step guidance for the structural design of the prefabricated bridge elements and systems. The sample calculations pertain to the same standard bridge configurations for steel and concrete in the ABC standard concepts. This provides the practitioner new to ABC with a comprehensive look at how ABC designs are carried out and translated into design drawings and details.

Recommended Specifications

LRFD Bridge Design Specifications does not examine the unique aspects of large-scale prefabrication, such as element interconnection, system strength, and the behavior of rapid deployment systems during construction. The SHRP 2 project identified shortcomings in *LRFD Bridge Design Specifications* that may limit the use of ABC designs but recommended ways to address these limitations. The LRFD specifications for ABC bridge design recommended in the toolkit have not yet been adopted by AASHTO.

The recommended LRFD construction specifications for prefabricated elements and modular systems include best practices compiled by the SHRP 2 project team for use with the standard concepts for steel and concrete modular systems. These specifications for rapid replacement focus on means and methods for rapid construction with prefabricated modular systems.

PHOTO: IOWA DOT

The Keg Creek Bridge replacement project reduced the road closure time from the conventional 6 months to 2 weeks.

First Pilot Project

US-6 Bridge over Keg Creek, Iowa

The SHRP 2 project included field activities to pilot the concepts developed for the ABC toolkit. The first pilot project was conducted in partnership with Iowa DOT on the US-6 bridge over Keg Creek in Pottawattamie County, approximately 6 miles east of Council Bluffs. Before identifying the site as a potential ABC pilot, Iowa DOT had designed a conventional cast-in-place replacement bridge; the design would have required an estimated 6 months for construction and road closure.

Working collaboratively with Iowa DOT, the SHRP 2 research team redesigned the ABC pilot bridge, applying several of the innovative concepts included in the ABC Toolkit. The replacement structure is a three-span steel precast modular bridge with precast substructures and precast bridge approaches.

Innovations Applied

The pilot project incorporated the following innovations from the ABC Toolkit:

- A complete bridge system was designed and constructed with superstructure and substructure systems of prefabricated elements. The bridge approach slab also was precast.
- High-performance concrete was used to enhance the durability of all precast components.
- The bridge has a jointless superstructure. Full-moment connections between precast components emulate cast-in-place construction, provide superior durability, and minimize long-term maintenance.
- Precast pier elements were connected in the field with grouted splice sleeve couplers, which are efficient, easy to construct, and ideally suited for rapid construction.
- UHPC was used for the longitudinal and transverse superstructure joints, to provide a durable, moment-resisting joint between deck panels. The Iowa project was the first in the United States to use UHPC to provide a full, moment-resisting transverse joint in the superstructure at the piers.
- Self-consolidating concrete was used to improve consolidation and increase the speed of construction for abutment and wingwall piles, or

Bridging a Creek, Entering the Mainstream

AHMAD ABU-HAWASH

The Iowa Department of Transportation (DOT) has a long history of forming partnerships with other transportation agencies in pursuit of innovative, practical, cost-effective, and implementable solutions for common problems in transportation infrastructure. These partnerships have included pooled-fund studies and demonstration projects and have helped Iowa DOT achieve its goals.

With funding available through federal programs, Iowa DOT began exploring accelerated bridge construction (ABC) in 2006 to replace some of its aging bridges. The majority of the department's ABC projects were completed with grants from the Federal Highway Administration's Innovative Bridge Research and Deployment and the Highways for Life (HfL) programs.

First Step

Phase 2 of the second Strategic Highway Research Program (SHRP 2) Project R04 on innovative bridge design for rapid renewal sought to demonstrate the ABC design concepts developed for moderate-size bridges. In late 2009, the research team proposed a demonstration project in Iowa as a first step to nationwide implementation of the ABC design toolkit, a collection of innovative, but proven, design concepts assembled in Phase 1 of the project.

The author is Chief Structural Engineer, Iowa Department of Transportation, Ames. He chairs the NCHRP Project Panel on Development of an Accelerated Bridge Construction Design and Construction Guide Specification.

Value and Impact

The SHRP 2 demonstration project gave Iowa an opportunity to apply the latest innovations backed by state-of-the-art research and testing by a team of national experts. Funding from SHRP 2 and HfL enabled Iowa to assume more risk in deploying the innovations.

The success of the demonstration project, and the national exposure that followed, have generated positive energy and motivated Iowa DOT to continue work in rapid renewal and accelerated project delivery. Although department managers already had provided strong support for Iowa's ABC initiative, the support increased with successes. As a result, Iowa DOT developed and implemented a statewide ABC policy in 2012. All bridge replacements in the state will be evaluated for ABC. Several projects have been identified as candidates, including a lateral bridge slide, a first in Iowa.

Demonstration Project

The US-6 bridge over Keg Creek in Pottawattamie County was chosen for the SHRP 2 demonstration project for its schedule, size, detour length, and location. The project was a perfect fit

fill pockets, and for abutment-to-wingwall connections.

◆ Fully contained flooded backfill was used to achieve rapid consolidation and to reduce significantly the potential for the formation of voids beneath the approach pavement.

Project Accomplishments

Construction of the bridge attracted seven bidders, indicative of the interest in rapid construction among local contractors in Iowa and of their ability to perform the work. Although the initial construction cost was higher than the engineer's estimate for conventional construction, the reduced installation time for the prefabricated bridge reduced the costs to highway users. Reducing the bridge closure from 6 months to two weeks also reduced traffic control costs, lightened the impact on the local economy, and improved safety. The bridge opened to traffic on November 1, 2011, after a 14-day closure for construction.[4]

[4] To view a time-lapse video of the Keg Creek ABC project, go to http://vimeo.com/33297963.

Second Pilot Project

I-84 Bridges over Dingle Ridge Road, New York

The second pilot project used the lateral slide method to replace the I-84 eastbound and westbound bridges, each with two travel lanes, over Dingle Ridge Road in New York. The replacement structure has three travel lanes in each direction. I-84 is heavily traveled, with an annual average daily traffic of 75,000.

The new bridge is a no-skew, 80-foot, single-span northeast extreme tee or NEXT beam superstructure, replacing a 135-foot, three-span steel girder superstructure. The semi-integral, closed-type abutments are contained by precast modular walls.

Conventional bridge replacement would have required several years and construction of a temporary bridge in the median at an estimated cost of $2 million. ABC eliminated the need for a temporary bridge and limited the traffic disruption to a single night for each bridge.

The site had critical underclearance issues; therefore the pilot also showcased a cost-efficient concrete superstructure system of NEXT double-tee

PHOTO: IOWA DOT

Precast bridge panels are installed on the US-6 bridge over Keg Creek Road in Iowa.

as a rural, moderate-size stream crossing similar to many bridges in Iowa, the Midwest, and many other states. The bridge was programmed for replacement in 2011.

Because of the bridge's narrow width, construction of the new foundation could occur outside the footprint of the old bridge without restricting traffic. Moreover, moderate size, simple geometry, and low traffic volume made the bridge attractive for demonstration.

The continuous concrete T-beam bridge was 180 feet long by 28 feet wide; the replacement structure is a prefabricated steel modular superstructure, 205 feet long by 44 feet wide, on a precast substructure supported on drilled shafts. Each of the 18 modular superstructure units consists of a precast concrete deck panel, composite with a pair of steel beams. The supporting substructure consists of precast pier columns and caps, with precast abutment footings and wings.

Precast concrete panels were used for constructing the bridge approach pavement. Grouted couplers connect the precast pier components, specifically the column to the cap and shaft. Another innovative feature is the use of ultrahigh-performance concrete (UHPC) in the longitudinal joint between modular units and in the moment-resisting joint over the piers.

The design concept allowed the contractor to innovate while using basic traditional construction techniques. Godbersen-Smith Construction Co. of Ida Grove, Iowa, the general contractor for the project, had extensive experience building cast-in-place bridges and constructed the superstructure as a single unit with blockouts to accommodate the eventual partitioning into modular units—something like a jigsaw puzzle.

The single superstructure unit was built off alignment in a farm field during the summer months, without interfering with traffic. The modular units were reassembled onsite in a few days, after closing the road to traffic.

Entering the Mainstream

One measure of Iowa DOT's success with the innovative technique is that future ABC projects will no longer be termed demonstrations or showcases, but simply projects built expediently and efficiently, with minimum inconvenience to the traveling public. By introducing the rapid renewal toolkit, SHRP 2 is providing important building blocks for bridge owners to renew the nation's aging infrastructure in a safer and less intrusive manner.

Photo copyright Andy Ryan, HNTB

Midway through the replacement of the I-84 bridge over Dingle Ridge Road, half the bridge rests on temporary supports while half has been placed onto permanent abutments.

prestressed concrete beams to minimize structure depth. The new techniques from the pilot will be added to the next edition of the ABC Toolkit.

Closure of the roadway crossing lasted 20 hours, mostly overnight, for each replacement, allowing rapid demolition of each bridge and the slide-in of the new superstructures. Maintaining traffic on the bridges during the fabrication and assembly of the new bridges off alignment minimized traffic disruption and the costs of work zone traffic control.

Site Work

Work on the new bridges commenced while the existing bridges remained in service. The approach slabs were designed to carry traffic temporarily after the slide-in and before the abutment backfill was completed. The slide-in bridge replacement required low foundation settlement tolerances to prevent cracking when the completed superstructure was moved on to the new abutments.

Two drilled shafts were installed at each abutment, one on each side of the former structure. A cast-in-place cap beam connected the two shafts and served as the slide surface and a platform for the bearings of the replacement structure.

Abutment drilled-shaft foundations and columns were constructed to the bearing elevation of the cap beam. With the columns in place, the precast modular walls were installed along the wing walls up to the elevation of the slide surface.

The bridge superstructure and approach slabs were constructed concurrently on temporary shoring with sliding tracks adjacent to the old bridges. The approach slabs, which consisted of precast and prestressed concrete modules, were connected with UHPC closure pours. The NEXT beams were supported on a cross beam and back wall cast integrally with the sliding shoes of the beam ends.

The abutments are designed to behave as semi-integral, with elastomeric bearings for expansion. In addition, the approach was widened from two to three lanes.

Sliding into Place

After the initial substructure was completed and the superstructure assembled, traffic was diverted for the overnight closure. The old bridge was demolished, and the two-lane approach was raised to the new profile. A precast sleeper slab was placed at either approach to serve as an end dam for the raised approaches and as a sliding surface for the approach slabs.

The superstructure and approach slabs were slid into place on low-friction pads. Jacks pushed the new superstructures on to the new abutments. The approach slabs were designed to take live loads temporarily, allowing the rerouting of traffic onto the new structure.

With the new structure in place and traffic restored, the substructure and approach roadway work were finalized. The remaining precast modular wall sections were placed along the abutment wing walls, up to the approach slabs.

Controlled low-strength flowable fill completed the backfill under the approach slabs and created positive contact between the approach slabs and underlying subgrade, under live traffic. Approach pavement work raised the widened roadway to the elevation of the raised section. A final 2-inch asphalt course was applied across the new approach roadways and bridge.

The ABC timeframe began with the closure of the crossing and ended with the rerouting of traffic over the new bridge. Each 20-hour closure occurred over a weekend, commencing Saturday night and extending through Sunday morning.

Innovations Slide into Place in New York State

WILLIAM J. GORTON AND NICOLAS A. CHOUBAH

The mission of the New York State Department of Transportation (DOT) is to ensure that those who live, work, and travel in the state have a safe, efficient, balanced, and environmentally sound transportation system. Accomplishing this mission requires ongoing improvements in infrastructure conditions through effective construction techniques.

In April 2011, after learning about the second Strategic Highway Research Program (SHRP 2) Project R04 on innovative bridge designs for rapid renewal, New York State DOT gained approval for a project on Interstate 84 (I-84) in the Hudson Valley Region, for a rapid renewal by lateral slide. After approval for the SHRP 2 project, the New York State DOT applied for an FHWA Highways for Life (HfL) grant, receiving approval for $2.1 million in July 2011. This allowed New York State DOT to leverage support for the innovative design. The SHRP 2 project included innovative bridge design by the consulting firm HNTB.

Project Goals

The project replaced two bridges, I-84 eastbound and I-84 westbound over the local Dingle Ridge Road. This section of I-84 near the New York–Connecticut border is heavily traveled. The annual average daily traffic (AADT) on I-84 at this location approaches 75,000.

New York State DOT originally planned to replace the two bridges with traditional construction techniques, placing a temporary bridge between the two structures, detouring traffic from eastbound I-84 to the temporary bridge, and then repeating the strategy for westbound traffic. This plan would require two construction seasons; the temporary infrastructure cost was estimated at approximately $2 million, including the temporary bridge and roadway systems.

New York State DOT wanted to use the innovative SHRP 2 accelerated bridge construction (ABC) lateral slide technique to reduce cost, improve safety, and minimize delay associated with the reconstruction, especially the maintenance and protection of traffic during construction. By eliminating the need for temporary roadways, the ABC techniques also offered a substantial environmental benefit to the New York City watershed. Moreover, the success of ABC could set a trend along the Interstate—many bridges in the corridor were built at the same time and exhibit the same level of deterioration.

New York State DOT opened bids for the project in November 2012 and received nine bids for the innovative construction contract, which included incentive and disincentive provisions to promote efficiency and adherence to the schedule. The number of bids indicated the quality and clarity of the construction details and specifications for the ABC approach. The low bid was $10.2 million.

PHOTO COPYRIGHT ANDY RYAN, HNTB

By eliminating the need for temporary roadways, the use of ABC techniques on the I-84 bridge in New York also reduced harmful environmental effects from the construction project.

Successes and Benefits

Despite preliminary concerns about making progress on the project using a consultant for design services under contract to SHRP 2, New York State DOT found that the teamwork was seamless, communication was open and ongoing, and the project proceeded on schedule. The project deadline and the priority of a demonstration project also may have enhanced progress. New York State DOT retained HNTB for support services essential to the construction phase, so that the leadership of the innovative project team remained in place until completion.

The ABC project design met the goals of reducing cost, improving safety, and minimizing the impact of construction. New York State DOT was able to eliminate the temporary bridge and roadway system between the two bridges, saving approximately $2 million. The innovative technique reduced delays and traffic queues by 96 percent from what would be projected with the construction activities under a traditional approach. The bridge geometry was maintained, except for two 20-hour periods in which the newly constructed superstructures were slid into place after the diversion of traffic. The ABC strategy saved more than $1 million in highway user costs, and the design reduced the traveling public's exposure to restricted work zones and minimized the safety risks.

The lateral slides for the two bridges were placed in fall 2013, and the goals for the project were met.

Gorton is Acting Regional Director, and Choubah is Regional Design Engineer, New York State Department of Transportation, Hudson Valley Region, Poughkeepsie.

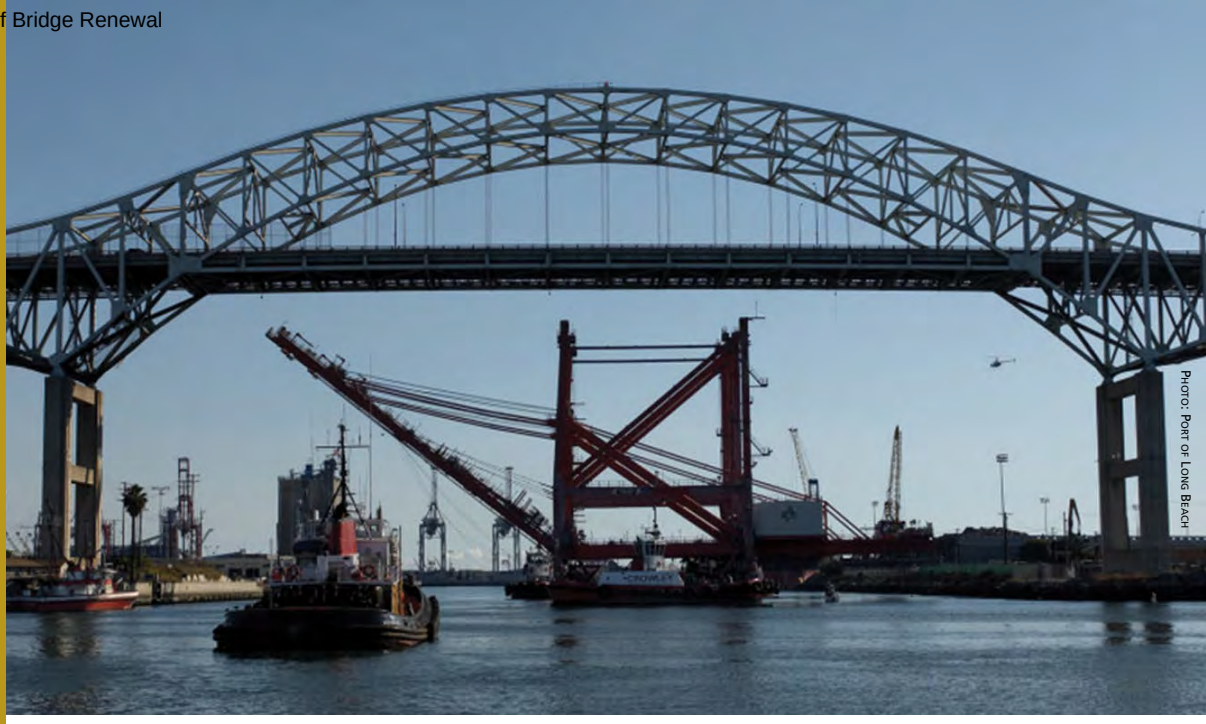


PHOTO: PORT OF LONG BEACH

(*Right*:) The Gerald Desmond Bridge today. The bridge was not designed to handle today's typical daily traffic of 58,000 to 68,000 vehicles. The replacement bridge is projected to carry 30 million vehicle trips per year.

Bridging Long Beach into the Future

Planning, Financing, and Building a Transportation Megaproject

ERIC C. SHEN

The Gerald Desmond Bridge is a critical piece in the trade and commerce infrastructure of the United States—nearly 15 percent of the nation's waterborne cargo passes beneath its span. Locally, the bridge is a major commuter thoroughfare, carrying 58,000 to 68,000 vehicle trips a day. The bridge, however, is old and out-of-date.

The State of California is replacing the steel-arch structure over the main channel of the Port of Long Beach with the state's first cable-stayed bridge. The new bridge not only will provide an effective infrastructure solution for today's traffic

IMAGE: PORT OF LONG BEACH

Artist's rendering of the Gerald Desmond Bridge replacement.

Shen is Director of Transportation Planning, Port of Long Beach, California. He chairs the TRB Ports and Channels Committee and is a member of the TRB Marine Group. He serves as adjunct faculty at the Viterbi School of Engineering and the Sol Price School of Public Policy, University of Southern California, Los Angeles.

demand but will stand as a beautiful addition to the city's skyline. After a decade of preparation, construction began in 2013, with completion scheduled for 2016–2017.

Vital Connector

When the Gerald Desmond Bridge opened in 1968, few could have imagined the surge in Transpacific trade that would make the Port of Long Beach and the Port of Los Angeles the two busiest seaports in North America, handling 40 percent of all container trade into the United States. With the region's rapid urban growth, the Gerald Desmond Bridge became a vital connector for the ports, the City of Long Beach, Southern California, and the nation. The U.S. Congress designated the bridge as a National Highway System Intermodal Connector Route and as part of the Federal Strategic Highway Network.

The Port of Long Beach—that is, the City of Long Beach Harbor Department—owns and maintains the current Gerald Desmond Bridge (see map, Figure 1, above right). At completion of the new bridge, the State of California will assume ownership of the structure and connectors, which will be maintained by the California Department of Transportation (Caltrans).

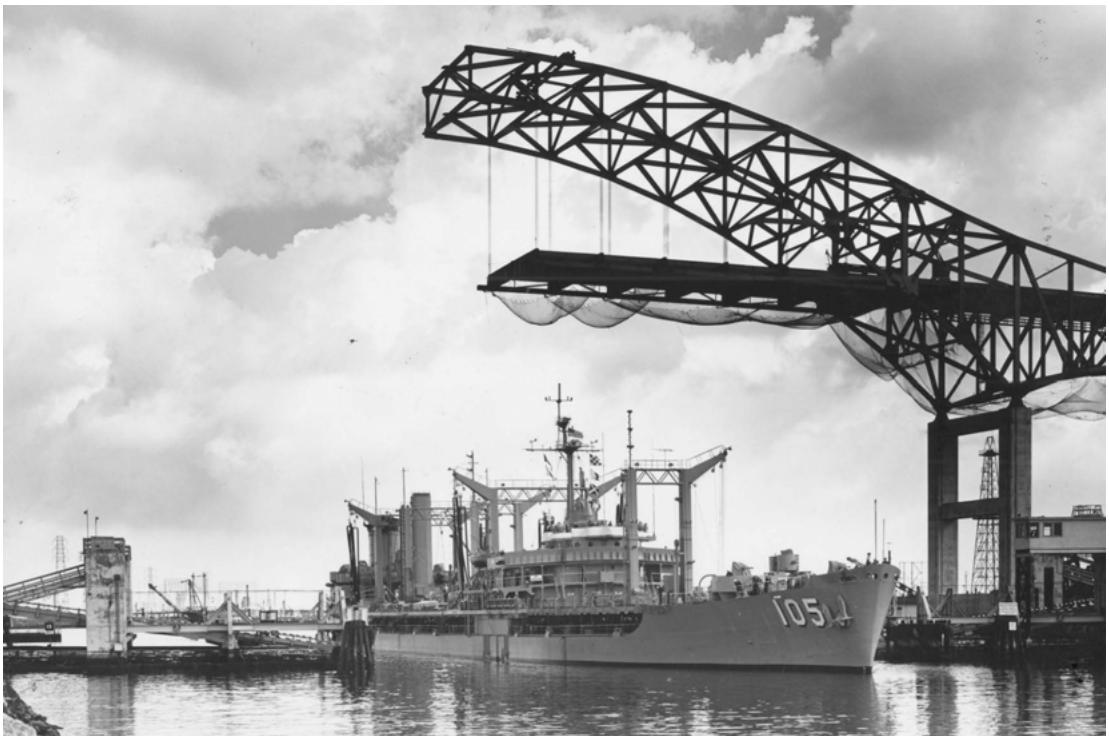
The new bridge, designed primarily to ease traffic congestion and improve safety, will be constructed adjacent to the current span, and the old bridge will be demolished after the new structure opens for traffic. The project is a joint effort of Caltrans and the Port of Long Beach, with additional funding from the U.S. Department of Transportation (DOT) and the Los Angeles County Metropolitan Transportation Authority (Metro).

FIGURE 1 Project location.

Investment Program

In 2010, the Port of Long Beach launched a $4.5 billion capital improvement program—the most extensive in the port's 102-year history—to be implemented over the next decade. The investment is the largest by any seaport in the country and will help Long Beach remain competitive as a gateway of choice in Transpacific trade, will improve efficiency, and will maintain environmental stewardship. The Gerald Desmond Bridge Replacement Project is one

PHOTO: PORT OF LONG BEACH



The Gerald Desmond Bridge under construction, 1967.

Photo: Port of Long Beach

Current bridge alignment.

of the major elements of the investment program, which includes the $1 billion Middle Harbor Redevelopment Project and other improvements.[1]

In August 2010, the port's Board of Harbor Commissioners unanimously approved the environmental impact report for the project. In November 2010, the California Transportation Commission approved the funding and building plans by the Port of Long Beach, clearing the way for the port and Caltrans to seek bids for design and construction of the new bridge.

Design–Build Procurement

The Gerald Desmond Bridge Replacement Project was the eighth project that the California Transportation Commission authorized under the state's design–build legislation SBX2 4, signed into law in 2009. The legislation created a transportation design–build demonstration program that authorizes best-value procurements for a limited number of projects. The method combines design and construction into one contract to expedite the project and—through time savings—reduce costs.

The port issued a request for qualifications to the international engineering and construction community on November 5, 2010. By March 2011, four of the seven teams that submitted qualifications were selected to continue in the procurement process. In September 2011, the port issued an extensive request for proposals to the four teams. Three teams submitted proposals in late February 2012; one chose not to pursue the project.

Evaluating Proposals

The proposal evaluation was conducted in three distinct approaches, because of the technical complexity and the multijurisdictional procurement requirements:

- The Tier 3 Technical Expert Panel (TEP) analyzed the technical parameters in each proposal. The TEP developed consensus comments only and did not rank, score, or compare proposals.
- The Tier 2 Pass–Fail Subcommittee analyzed each proposal in terms of the pass-or-fail criteria and developed a consolidated set of recommendations for each proposal.
- The Tier 2 Technical Scoring Subcommittee assigned adjectival scores for each evaluation criterion.
- The Tier 1 Project Selection Committee oversaw the entire evaluation and selected the best-value proposal.

On May 4, 2012, the Project Selection Committee recommended selection of the proposal from the joint venture team headed by Shimmick Construction Company, Inc.; FFC Construction, S.A.; and Impregilo S.p.A. (SFI), with subcontractors Arup North America, Ltd., and Biggs Cardosa Associates, Inc. The Port of Long Beach's Board of Harbor Commissioners gave final approval on July 23, 2012, and awarded the $649.5 million design–build contract.

Expected Benefits

The new bridge will provide many benefits. Three lanes in each direction and emergency lanes on both sides will greatly improve traffic flow and reduce delays from safety hazards such as accidents and vehicle breakdowns. The current bridge has two lanes in each direction, plus a merger lane, but no emergency lanes. The new span also will include

[1] For more details, www.newgdbridge.com.

bicycle and pedestrian paths, as well as three observation decks.

The vertical clearance will increase from 155 to 205 feet, allowing today's larger, greener ships to access the inner harbor shipping terminals. The new design offers shallower grades, so that drivers will not have to accelerate as much, reducing pollutant emissions. Construction will incorporate state-of-the-art, green technology and the latest in seismic engineering.

Interstate 710 (I-710), the Long Beach Freeway, is the main thruway for trucks coming in and out of the port complex. When the reconstruction of the Terminal Island East Interchange and the I-710–Gerald Desmond Bridge Interchange, along with the improvements to the State Route 47–Interstate 110 connector, are completed in 2018, traffic will flow more safely and smoothly through the port complex.

For each of the four years of construction for the new bridge and demolition of the current Gerald Desmond Bridge, the project is expected to generate nearly 3,000 construction-related jobs. According to an analysis by the Los Angeles Economic Development Corporation, the $1 billion in spending will sustain economic activity of more than $2 billion in Southern California.

Financial Plan

Securing funding for this massive project has been a primary challenge. A combination of federal and state funds, as well as port revenues, will finance the new bridge (see Figure 2, above right).

The federal government historically has financed the majority of projects that improve access to major transportation facilities, such as roads, waterways, and bridges to seaports or airports. The port, however, had funded and maintained projects within the Long Beach harbor district, such as on-dock rail and interchanges, with its own revenues. The arrangement made sense, because the facilities directly connected to port operations.

The Port of Long Beach has agreed to contribute significant funds for the replacement of the aging Gerald Desmond Bridge and to fund the operations and maintenance costs for 30 years after the state takes ownership of the new bridge. In Fiscal Year 2012, the port applied for a Transportation Infrastructure Finance and Innovation Act (TIFIA) loan; the process is expected to be completed later this year. The TIFIA loan and additional revenue bonds issued by the port will be the primary sources of local funds.

Toll Options

Although locally owned, the Gerald Desmond Bridge is a nationally significant transportation link, and its replacement costs far exceed the port's financial resources. The port and its project partners considered alternative funding options, including user tolls. During the project development phase, a series of economic analyses and traffic simulations on several tolling scenarios revealed that nominal toll revenues could be collected to help fund the replacement cost.

Nevertheless, tolls would have an adverse effect on neighboring communities. According to the analysis, even a passenger vehicle toll of less than $2 would cause significant diversions, with drivers opting for local streets and freeways such as I-405, I-110, and State Route 91, to avoid the toll. The approved environmental report clearly described the tolling option as not feasible.

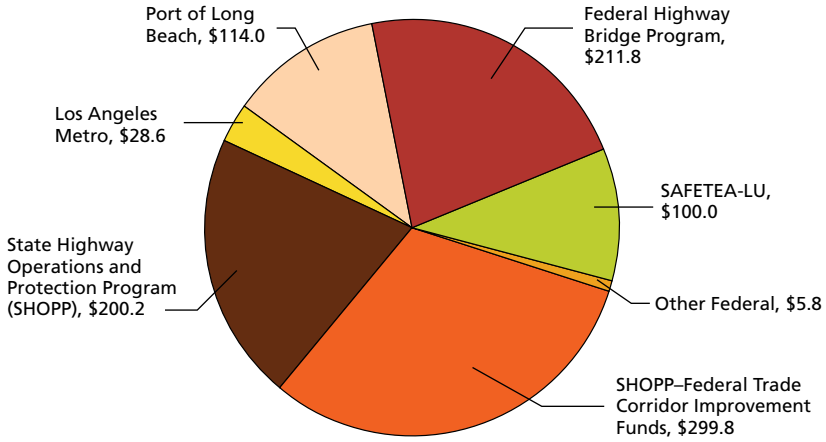


FIGURE 2 Port of Long Beach Gerald Desmond Bridge project funding plan for a total $960.2 million as of November 2011 (contributions in $ millions). (SAFETEA-LU = Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users.)

IMAGE: PORT OF LONG BEACH

Artist's rendering of bicycle lanes and pedestrian access on the new bridge.

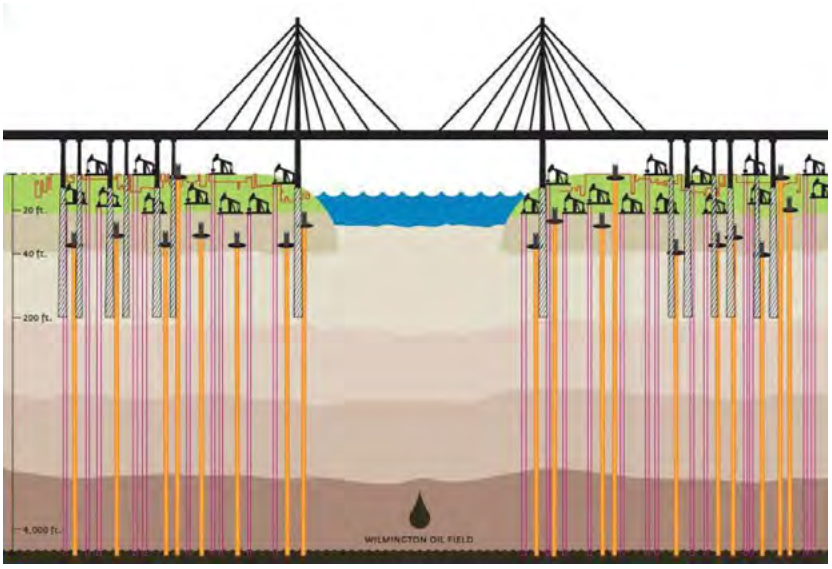


IMAGE: PORT OF LONG BEACH

FIGURE 3 Building the new bridge over an active oil field.

Cargo Fees

In 2007, the ports of Long Beach and Los Angeles considered assessing an infrastructure cargo fee (ICF) on container and bulk cargo moving through the ports. The revenue raised from the goods movement industry would pay for approximately half of the costs of an approved list of highway and rail improvements, including replacement of the Gerald Desmond Bridge.

The ports would levy the ICF on import or export cargo moving by truck or rail through the terminals. Revenue from the fees would be matched by local, state, and federal funds to help pay for the projects. The ICF would sunset after all the projects on the list were completed and paid for.

The proposed fee would begin at $15 per loaded 20-foot-equivalent unit (TEU) container and would range between $10 and $18 per TEU over a seven-year period. The economic recession that hit the United States in 2008 and later the rest of the world reduced trade volumes by as much as 30 percent from the peak in 2007. Charging additional fees to an industry already recording massive losses did not make business sense, and both ports postponed the ICF for a few years.

In late 2013, both ports decided to remove the ICF from their tariffs, to maintain price competitiveness with other U.S. ports. Although the new bridge will provide significant benefits to cargo to and from both ports, only the Port of Long Beach is contributing to the funding gap.

Building over an Oil Field

The new 1.5-mile-long bridge is being built atop the nation's third-largest oil field, discovered in 1932. Twenty-three active and idle wells lie in the path of the new bridge (see Figure 3, left). The port must relocate or abandon the wells to clear the way for the contractor to drive 300 piles deeper than 200 feet into the ground for the bridge foundation.

Because of legacy agreements between the City of Long Beach and oil field operators, the design–build contract solicitation could not include the relocation of the oil wells. If the relocation had been included, the contractors likely would have built-in significant contingency to cover the risks. As is, the related oil field costs have increased to $239.5 million, far exceeding the initial estimate of $105 million.

Challenges Moving Forward

As with any large infrastructure project, particularly with design–build delivery, the challenges are to manage interrelated tasks involving multiple regulatory and permitting entities and to identify areas for streamlining. The most effective solutions, however, often do not become obvious until the project is mature and under way. A project of this complexity and magnitude takes a considerable amount of time to develop; the port began scoping the replacement bridge and preparing the environmental assessment in 2000.

The project had a funding gap of nearly $300 million until mid-2008. Without the leadership of many elected officials and the determined teamwork of many agencies, the project could not have achieved the full funding commitment or completed the extremely compressed procurement process in 2011.

The bridge construction began in early 2013 in the midst of an active, operating port complex, with cargo volumes slowly returning to prerecession levels. Managing traffic safely around the active construction zones and minimizing the delays to port trucks is as great a challenge as building the bridge itself.

Model for Problem Solving

Institutionally, the Port of Long Beach, Caltrans, and U.S. DOT continue to work closely together to address issues throughout the project and to define roles and relationships. Alternative technical concepts often demand special consideration beyond standards and manuals, and decisions often require buy-in from partnering agencies and proactive legal support. Coordination, collaboration, and cooperation among all stakeholders are essential to complete this historic and nationally significant project.

With all of the ins and outs of planning, funding, permitting, designing, and constructing this transportation megaproject, the Gerald Desmond Bridge Replacement will yield many lessons and serve as a model for subsequent large-scale problem solving.

Scott Towery, Flickr

Energy Sector Impacts on Road Infrastructure in Texas

Wind Power, Natural Gas, and Oil Production Driving Traffic

JOLANDA PROZZI, AMBARISH BANERJEE, SERGEY GREBENSCHIKOV, AND JORGE PROZZI

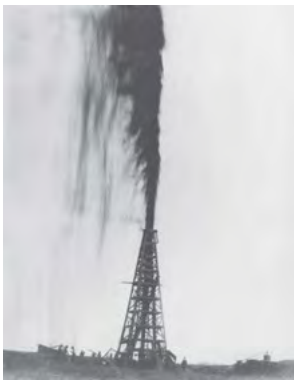
Jolanda Prozzi is Program Manager, Environment and Planning, Texas A&M Transportation Institute, Austin. Banerjee is a consultant with AgileAssets, Inc., Austin, Texas. Grebenschikov is Civil Engineer, CH2M Hill, Chicago, Illinois. Jorge Prozzi is Associate Professor, University of Texas, Austin.

The Lucas Number 1 well blew mud, gas, and oil 200 feet into the air at Spindletop, Texas, on January 10, 1901, and the energy sector became a major contributor to the state's economy. Today, Texas produces approximately 30 percent of the natural gas consumed in the United States and accounts for 19 percent of the nation's total oil production.

During the early 1900s, oil discoveries spread through North, East, and West Texas; today, innovations in production technologies have allowed the mining of the unconventional gas plays in the Barnett Shale region of Arlington and Fort Worth, the Haynesville Shale region of East Texas, and the Eagle Ford Shale of South Texas. As a result, the oil and natural gas sectors are expected to continue to be major contributors to the state's—and the nation's—economy.

(*Photo, above:*) New techniques such as zipper fracturing, which draws from two or more parallel wells, have allowed the mining of the natural gas play in Eagle Ford, Texas.

Photo: University of Texas at Arlington Library, Portal to Texas History



The Lucas Gusher in Spindletop, Texas, in 1901. Today Texas produces nearly 20 percent of the nation's oil.

PHOTO: FREDLYFISH4, WIKIMEDIA COMMONS

The Roscoe Wind Farm in Texas has more than 600 wind turbines and is among the largest wind farms in the world in terms of capacity.

Concerns about energy security, air quality, and carbon emissions, however, have led the Texas legislature to adopt policies promoting the development of renewable energies. Texas is the nation's leading producer of wind energy, with a rated capacity of more than 10,000 megawatts in West Texas and the Texas Panhandle. Other renewable energy sources, such as biomass-fueled electricity, biofuel production, solar energy, and geothermal energy, are in development in other regions of the state, although on a smaller scale.

Components and Products

The state's road infrastructure has played a critical role in supporting and facilitating the development of these energy reserves. The roads have facilitated the moving of components during the construction and development of an energy source and subsequently the intermediate and final products in some of the energy supply chains.

The energy sector has placed significant demands on the Texas transportation system. The oil and gas industry, for example, requires the delivery of equipment and water to the drilling sites and the removal of brine water from the well sites.

Concerned about the impact of these trucks on the road infrastructure, many cities—for example, in the Barnett Shale area—have required bonds from the energy companies that are drilling, to maintain the integrity of the roadway. Similarly, rural roads in West Texas and the Texas Panhandle are carrying an increased number of oversized and overweight (OS-OW) trucks serving the development of wind farms.

The Texas Department of Transportation (DOT) sought to understand how the state's transportation system serves the energy sector and how the sector affects the transportation system. In 2009, Texas DOT funded a study to illustrate and quantify the impacts.

Energy Sector Road Use

Focusing on the most prominent energy industries—wind, natural gas, and crude oil—that rely on the road infrastructure, the study team isolated the operations involved in the construction and development of the infrastructure for each energy source and in the

PHOTO: NIELS VAN ECK, FLICKR

Trucks transporting wind turbine blades and other wind turbine components, mostly on Interstate highways, must obtain oversize and overweight permits.

TABLE 1 Road Movements Associated with the Energy Sector

Energy Sector	Operation	Description
Wind energy*	Movement of wind turbines	OS-OW loads; tower, blades, nacelle, hub and rotor
Natural gas	Movement of drill rig	OS-OW loads; movement of drill rig
	Construction traffic	Transportation of frac sand, frac water, aggregates, concrete, etc.
	Saltwater removal	Saltwater removal from well site to injection wells
Crude oil	Construction traffic	Rigging up, rigging down, movement of drill rig, building access roads, etc.
	Production traffic	Transportation of the crude oil from the tank farm to the pipeline breakout stations

*Data on the construction of wind turbine pad sites were not available.
Note: OS-OW = oversize–overweight; frac = fracturing.

distribution of the energy resources. Of particular interest were the characteristics of the vehicles used, the distances traveled, and the types of roads used—for example, Interstate highways, U.S. highways, state highways, or farm-to-market or local roads. The table above illustrates the operations and data obtained.

Wind Turbines

OS-OW trucks typically move wind turbines. Approximately nine OS-OW truck permits are required to haul the turbine components, including the tower, blades, nacelle, hub, and rotor. An analysis of a random sample of OS-OW truck permits for moving wind turbine components in Texas reveals an average trip length of approximately 415 miles, almost 50 percent of which occurs on the Interstate Highway System. Only 6 percent of the distance is traveled on lower functional highway facilities, such as the farm-to-market system, county, and other local roads.

Most of these components are imported through the Texas ports of Corpus Christi, Houston, Galveston, and Freeport and then move by highway to West Texas and the Texas Panhandle, sites of most of the wind developments. This generates the relatively long travel distances.

PHOTO: PATRICK FELLER, FLICKR

Wind turbine blades wait at Freeport, Texas, for transport to other parts of the state.

Natural Gas

Natural gas production in Texas is a complex, multistage operation. Most of the natural gas resources are trapped in porous shale formations and are referred to as unconventional gas (see box, below). Seismic exploration first determines the most economically suitable locations for drilling.

A pad site and an access road are prepared for the construction and drilling traffic. The drill rig is delivered in several sections and requires approximately 20 OS-OW permits; assembly is on site.

On average, a drill rig travels approximately 33 miles via all four major functional highway classes—Interstates, U.S. highways, state highways, and farm-to-market roads—for similar distances. When the drilling begins, trucks deliver steel piping and cement for casing and cementing the well hole to prevent groundwater contamination. Trucks also deliver mud for lubricating the drill.

If determined to be economically viable, the well is perforated, and hydraulic fracturing begins. In the Barnett Shale area, a typical well requires approximately 3.05 million gallons of water for drilling and hydraulic fracturing. Most of the truck traffic—approximately 685 loaded tankers—transports the so-called frac water and frac sand.

Another major generator of truck traffic in the Barnett Shale region—and in other unconventional natural gas shale plays—is the disposal of the production water, the salt water used to stimulate the flow of hydrocarbons during the hydraulic fracturing. Throughout its life, a natural gas well produces water, referred to as backflow; typically, a tanker trucks the backflow from the well site to a Class II salt water disposal well.

The average distance between the natural gas well site and the salt water disposal wells is 9.4 miles, but most of the distance is traversed on the lower functional road classes—with 30.7 percent on local city streets and 24.8 percent on farm-to-market roads.

Almost all natural gas in the United States—approximately 95 percent—is distributed from the well to its final destination through a network of pipelines. Truck, rail, or barge transportation of natural gas requires conversion of the gas into liquid—which occurs at approximately –260°F; specially outfitted tanker units are required for the hauling. Natural gas, therefore, is rarely transported by road.

PHOTO: COMMONS.WIKIMEDIA.COM/JOSHUA DOUBEK

Fracking the Bakken Formation in North Dakota

Hydraulic Fracturing

Technological advances in drilling methods and techniques have allowed for the extraction of natural gas locked in tight, impermeable shale. As a result, gas production from these unconventional reservoirs has increased dramatically. The techniques involve horizontal drilling and hydraulic fracturing, also known as fracking. The process pumps air, water, and sand under high pressure into a well hole to fracture the thick shale and stimulate the flow of natural gas.

Oil Production

Most of the oil production in Texas today occurs in the Permian Basin through tertiary recovery. The construction and production operations in the mining of crude oil use the Texas road system. The well development process involves site preparation, rigging up, drilling, and rigging down.

The construction operations generate approximately 1,054 two-way truck trips. An analysis of a random sample of OS-OW permitted routes revealed an average trip of 87 miles for hauling oil well equipment in the Permian Basin. Most of the distance is traveled on U.S. highways (28.1 percent), state highways (28.6 percent), and farm-to-market roads (24.4 percent).

Production traffic involves the transportation of crude oil from the tank batteries to the pipeline breakout facilities. The Permian Basin yields approximately nine barrels per well per day; this requires a single 6,000-gallon truck every two weeks to move the mined oil from the well to a pipeline breakout facility.

The average trip distance is approximately 18 miles, mostly on U.S. highways (21 percent), state highways (27 percent), farm-to-market roads (20 percent), and county roads (10 percent). Wells in the Permian Basin produce substantially less saltwater than the natural gas wells in the shale regions of Texas; moreover, the saltwater produced in the Permian Basin region is reinjected into the wells to maintain reservoir pressure and production levels.

Energy Sector Road Impacts

To quantify the impacts of the energy sector on the road system, the study team used the *Mechanistic–*

Photo: Bruce Gordon, SkyTruth/EcoFlight

Drilling activity in the Permian Basin, which accounts for most of Texas' oil production. Roads at each site must be able to handle approximately 1,054 two-way truck trips.

Empirical Pavement Design Guide. The impacts from the truck traffic generated by the operations associated with the wind, natural gas, and oil industries were expressed in terms of the reduction in the service life of the pavements in each highway functional class.

The movement of turbine components for the wind energy industry reduces the average pavement service life of Interstates by 1.9 percent, of U.S. highways by 15.2 percent, and of state highways by 20.2 percent. The average distances from the Texas ports to the wind farm developments in West Texas and the Texas Panhandle, however, are comparatively long. The pavement impacts, therefore, are systemwide.

In contrast, the impacts of the natural gas or crude oil industries typically are confined to a specific region. For the natural gas industry, the reduction in pavement service life associated with the development of one well site ranges from 1 to 16 percent for rig traffic, 4 to 53 percent for construction traffic, and 1 to 34 percent for saltwater traffic.

Farm-to-market and county roads experience the most severe impacts. These lower highway functional classes are not designed for the volume or weight of the truck traffic associated with the natural gas industry.

The production traffic associated with transporting crude oil from tank batteries to pipeline breakout stations reduces pavement service life by 2 percent to 16 percent; again, the greatest impact is on the farm-to-market roads. Construction traffic associated with well development reduces the pavement service life by 1 percent to 3 percent, depending on the class of highway. The construction traffic that comprises the OS-OW loads for the drill rig and the trucks for the materials and equipment has a negligible impact on the service life of the road system.

Evaluating Strategies

The thriving energy sector in Texas is the product of many decades of resource discoveries and innovative production practices, supported by the state's road system. The current levels of funding and the way that funds are allocated to transportation, however, may not be able to sustain the continued impact of the energy sector on the state's road infrastructure and the continued ability of the road system to serve the industry.

To address this issue, Texas DOT has formed an Energy Task Force to evaluate strategies, including strategies for funding, to maintain the road infrastructure and to ensure that the state's road system will continue to facilitate and serve the energy sector.

Acknowledgment

This article is based on research conducted for a study funded by the Texas Department of Transportation, "Impacts of Energy Developments on the Texas Transportation System Infrastructure," completed in October 2011.

Ethanol Production and Wind Energy

Challenging Low-Volume Roads in Iowa

MARK J. NAHRA

The author is County Engineer, Woodbury County, Iowa.

PHOTO: CHRIS YUNKER, FLICKR

(*Photo, above:*) Most of Iowa's county roads have granular surfaces and are used for farm traffic.

More than 89,000 miles of roads in Iowa are under the jurisdiction of counties; 69,000 miles of these roads have granular surfaces. Most were constructed to meet a gravel road standard established to "get Iowa out of the mud." The gravel roads traditionally are used for hauling crops in the fall to the nearest paved road for delivery to grain elevators near rail lines.

Many county paved roads were constructed in the 1960s near the rail corridors and grain terminals along the Mississippi and Missouri Rivers. The design standards allowed for relatively thin pavement. Counties still rely on 6-inch portland cement concrete pavements and on thin asphalt pavements.

Changing Traffic Patterns

The recent energy crisis and the increased interest in alternative, sustainable energy sources have led to dramatic changes that affect traffic patterns.

- Corn yields have increased with the genetic engineering of crops and improvements in farming techniques; Iowa produces more than 3.5 billion gallons of corn-based ethanol per year, leading the nation.
- The ethanol industry in Iowa employs approximately 85,000 people.
- The ethanol plants require delivery of grain 365 days per year. During the spring thaw, roads are unstable and can deteriorate rapidly under the repeated loads, but the producers continue hauling, despite the weather and road conditions, to meet delivery deadlines.
- With the shift in the economy, rail has become less important for crop transportation.

The ethanol plants are located close to corn production in areas not previously served by the developed paved road system. As a result, the production of billions of gallons of ethanol from corn has placed a tremendous strain on Iowa's low-volume roads for the delivery of raw materials and the shipping of the finished products. Because ethanol is highly corrosive, pipelines are impractical.

Many plants can store only a two-week supply of corn for production. Iowa has established a maximum weight of 20,000 lb per axle for licensed vehicles such as straight trucks and tractor-semitrailer units. To meet the demand for grain to supply ethanol plants, some producers have used other farm

equipment to transport crops, taking advantage of the higher axle loads allowed. For example, grain carts and wagons towed by large farm tractors can carry up to 28,000 lb per axle per vehicle.

Rural county pavements, gravel and dirt roads, and rural road bridges, however, were not designed to accommodate these loads or the levels of multiaxle vehicle loads. Many county roads are deteriorating at a faster rate.

Construction Hauling

Construction related to wind turbine sites also has increased traffic and vehicle loads. Many rural roads have proved inadequate for hauling the vanes—which can be up to 120 feet long—for the electric generators. Another problem is the enormous weight of the transformers and the switch gear.

The 66-foot-wide rights-of-way of most roads in Iowa cannot accommodate the turning maneuvers for the turbine vanes; rural intersections also are too tight to negotiate. The transformers require trucks with dozens of axles. When turning, the long-bed, multiaxle trucks carrying transformers and switch gear can tear up the gravel and dirt roads and leave mud behind, because the road surface cannot support the loads.

In addition, each turbine requires at least 400 cubic yards of concrete, tons of reinforcing steel bars, and gravel for constructing the windmill foundation. Transport of these raw materials subjects rural roads to heavy loads. Delivery of the large lattice-boom cranes to assemble the turbines also has proved problematic.

The increased loads are crushing the roads' aggregate structural prism, squeezing and pushing the aggregate to the side, causing rutting. Temporary roads often are built to carry the components to the generating stations. Iowa is second to Texas for wind-generated electricity.

Raising Funds

Research into the impact of alternative energy development in Iowa has estimated that road costs increase by $5,000 for each energy-related job. Property taxes generate much of Iowa's funding for road maintenance. The nominal 10- to 15-year tax abatement for the energy industry, however, yields no revenue to offset the costs for the county. In some cases, cities have selectively annexed new energy facilities, but this has not produced the funds needed to pay for the damage to county roads.

In Story and Delaware Counties, communities near proposed ethanol plants annexed the road rights-of-way instead of annexing adjacent properties between the city limits and the new plant sites to capture the taxable valuations of the new facilities. This strategy encloses the ethanol plant or wind turbine site within the corporate limits, increases the taxable valuation available to the city, and adds minimal responsibility for the roadway maintenance.

PHOTO: NATIONAL RENEWABLE ENERGY LABORATORY

Installation of a wind turbine near Charles City, Iowa. The weight and large size of turbine components put a strain on rural roads.

PHOTO: DEPARTMENT OF ENERGY

Wind turbines at Storm Lake, Iowa. Energy-related traffic leads to sharp increases in road costs in the state.

Repairing Damaged Rural Roads in Pennsylvania

Gas Companies Learn to Add Environmental Sensitivity to Durability

TIM ZIEGLER

The author is field operations specialist, Center for Dirt and Gravel Road Studies, Pennsylvania State University, University Park.

The active development of the Marcellus Shale natural gas play may prove to be an economic boom for Pennsylvania that will rival or dwarf the state's historic booms in other extractive industries, such as coal and timber. The technological development that allows the economically feasible recovery of deep shale gas reserves has triggered a mass migration of trucks and heavy equipment into the state.

Like the historic timber and coal booms, this activity is occurring mainly in the most rural parts of the state, using many dirt, gravel, and so-called "pie crust" roads, which consist of a thin layer of asphalt over native soil subgrade. The impact of gas industry truck traffic on these roads has been significant, but not unexpected. The companies developing the Marcellus Shale gas play understand the equipment and the infrastructure needs and concede that the road damage and the associated repairs are part of the cost of recovering the resource.

Repairing the Damage

The gas companies in Pennsylvania have upheld their responsibility to repair the damage, often restoring a road to a condition better than before the companies' arrival. Traffic delays, temporary rough roads, mud, and dust are now more commonplace in parts of rural Pennsylvania, but taxpayers are not burdened with the road repair costs associated with gas drilling. Good roads and good public relations are important to the companies, which are spending millions of dollars on road improvements in the state.

PHOTO: GERRY DINCHER, FLICKR

The large number of heavy trucks, Pennsylvania's many freeze–thaw cycles, and the year-round industry operations require roads that are structurally capable of supporting heavy loads at any time. Most of the state's rural roads were not constructed to carry the weight or the volume of traffic for the development of shale gas; many of the roads were only improved wagon paths. As a result, much of the road reconditioning and repair work by the gas industry has emphasized base stabilization to increase the strength of the roads.

Although a hauler is only legally required to repair a road to the prehaul condition, the gas companies generally have exceeded the minimum requirements of base reinforcement and surface treatments. Taking care of this infrastructure and the communities in which the companies operate is good business.

At right, a road in Tioga County, Pennsylvania, that was improved by gas companies drilling in the Marcellus formation in Pennsylvania; below, many large vehicles are needed to service a drill pad.

PHOTO: DOUG DUNCAN, U.S. GEOLOGICAL SURVEY

Photo: Center for Dirt and Gravel Road Studies

Heavy vehicles such as water trucks contribute to road surface deterioration; new techniques such as water piping can reduce the traffic load.

Changing the Approach

Marcellus gas development started in 2008, and with relatively limited traffic and a warm winter, few structural road problems were reported. In spring 2010, however, the ground thawed in less than 24 hours, causing significant road failures across the state's northern tier; the roads often were impassible.

The Pennsylvania Department of Transportation (DOT) began to examine more closely the gas industry's methodology of road use and repair—a "break it and fix it" approach. The industry had understood the hauling requirements but not the type of roads or the climate effects. In contrast, Pennsylvania DOT officials understood the roads and the specific maintenance challenges but not the scale of the industry's heavy hauling needs.

A 21st century industry was colliding with Northern Pennsylvania's 19th century unpaved and pie-crust roads. The industry and transportation officials have worked together to develop a better understanding of conditions and expectations, and the situation has improved markedly in the past two years.

In addition, depressed natural gas prices have slowed activity and have taken the focus off of the industry and its impacts on roads. Ongoing changes in production practices, such as flow-back recycling and the piping of fresh water, also have decreased the number of trucks on the road.

Attention to Drainage

The current situation appears to be manageable. Improvements are needed, however, to increase the implementation of prehaul road upgrades, to reduce the public's exposure to damaged roadways, and to minimize the environmental impacts on water quality from damaged roads and dysfunctional drainage systems.

As part of prehaul upgrades and posthaul repairs, companies have an opportunity to maintain or restore natural drainage patterns to minimize the transport and delivery of sediment into surface waters. Many road upgrades, however, have focused on structural reinforcement and road surface improvements. More effort is needed to improve and implement road drainage designs and practices to reduce the negative environmental impact of these structures.

The Center for Dirt and Gravel Road Studies at Pennsylvania State University has launched an educational outreach to municipal officials and the gas industry to promote environmentally sensitive maintenance (ESM) with improved road drainage. ESM works with natural systems to minimize the negative environmental impact on the road while reducing the road's negative impact on the environment.

Although roads affect surface hydrology and surface water quality, stormwater management and innovative drainage practices on rural public roads commonly receive less attention than do other land uses of similar scale. The Center for Dirt and Gravel Road Studies is working to change this.

Bridge Deterioration

Among the road-related issues associated with shale gas development in Pennsylvania is accelerated bridge deterioration from the increased heavy loads. Monitoring the deterioration and assigning responsibility for repairs of bridges is more complicated than for roads. Pennsylvania has a large number of bridges that are structurally deficient or functionally obsolete, and the state's budget would be challenged to address the repair and replacement of even more of these costly structures. This could likely become the next major transportation infrastructure concern related to energy development in the state.

Photo: Center for Dirt and Gravel Road Studies

Congestion of gas industry service vehicles and regular traffic on a low-volume, unpaved township road.

NEW TRB SPECIAL REPORT

Effects of Diluted Bitumen on Crude Oil Transmission Pipelines

THOMAS R. MENZIES, JR.

Menzies is Senior Program Officer, Transportation Research Board, and served as study director for this project.

PHOTO: JASON WOODHEAD, FLICKR

A large network of pipelines transports crude oil from Canada to refineries in the United States.

An estimated 55,000 miles of transmission pipelines in the United States primarily carry crude oil. Many of these pipelines run through the center of the country, carrying crude oil from offshore platforms and ports on the Gulf of Mexico, as well as from production regions in Texas and Western Canada to refineries along the Gulf Coast and the Great Lakes.

In recent years, the sourcing of crude oil has changed dramatically, with new domestic supplies tapped from the shale plays in Texas and North Dakota and with an increase in imports from Western Canada. The rapid shift in crude oil sourcing has had a significant effect on the transmission pipeline network, increasing the demand for capacity in pipelines running from the north to the south.

Diluted Bitumen in Pipelines

The imports from Western Canada, in particular, tend to be highly viscous, or heavy, crude oils that require specialized refining capacity, much of which is located along the Gulf Coast of Texas. An increasing percentage of these crude oil imports consists of bitumen extracted from the oil sands region of the province of Alberta. Plans by the TransCanada Pipeline Company to build a new, high-capacity pipeline, known as the Keystone XL, to connect the oil sands region to the Gulf Coast refineries, however, have generated public controversy, including questions about the effect of bitumen on pipeline integrity.

Bitumen is a dense and viscous form of petroleum that must be diluted with light oils to flow through unheated pipelines. Pipelines have transported diluted bitumen from Alberta to U.S. refineries for more than 30 years, mainly to facilities in the Midwest.

Federal legislation enacted in January 2012 called on the Pipeline and Hazardous Materials Safety Administration (PHMSA) of the U.S. Department of Transportation to determine if the likelihood of a

release increased for transmission pipelines transporting diluted bitumen.[1] PHMSA asked the Transportation Research Board (TRB) of the National Academies to inform the assessment by convening a committee of experts (see box, page 50) to examine the chemical and physical properties of bitumen diluted for pipeline transportation and any evidence that shipments of this product increase the chances of a pipeline failure that would result in a release. The National Research Council's Boards on Energy and Environmental Systems and on Chemical Sciences and Technology assisted in the study, released as TRB Special Report 311, *Effects of Diluted Bitumen on Crude Oil Transmission Pipelines*.

Study Approach

PHMSA mandates the reporting of accidental releases from U.S. transmission pipelines and categorizes each release according to its immediate, or proximate, cause. Historically, about one-third of reported releases involve forms of corrosion damage. Other causes of releases include damage by outside forces, such as an excavator striking a buried pipe, and faulty equipment, operator error, and deficiencies in welds and other materials used in the manufacture and installation of pipelines.

Incident Data

The committee reviewed U.S. and Canadian pipeline release statistics and investigations for evidence that shipments of diluted bitumen, or heavy oils with similar properties, are associated with a higher occurrence of releases from transmission pipelines. The incident data alone, however, were not sufficient for determining whether pipelines transporting diluted bitumen were more likely to experience releases.

Few of the incident records contained information about the type of crude oil released, and few documented the variety of crude oils transported through the pipeline over its history. Because many pipeline degradation processes, such as corrosion, are time-dependent, this history is important. Causal details also were limited. Incidents categorized as corrosion damage, for example, did not specify the underlying causes, such as the action of microorganisms, stress cracking, or preexisting mechanical damage. Although the incident statistics revealed the main causes of pipeline failures, the causal categories lacked the specificity necessary to assess the ways in which transporting a specific type of crude oil can affect a pipeline's susceptibility to failure.

[1] Public Law 112-90, enacted January 3, 2012.

Chemical and Physical Propoerties

The committee assessed the potential effects of the properties of the transported oil on each of the main causes of pipeline failures exhibited in the incident data. Consideration was given specifically to chemical and physical properties that can contribute to internal degradation, external degradation, and mechanical damage in pipelines.

Because it comes in contact with the transported oil, the inside of the pipe is the most obvious place to search for potentially adverse effects. Corrosion is the main cause of internal pipeline degradation, followed to a lesser degree by erosion. The properties of the shipped product also can affect some other causes of failure—for example, external corrosion and cracking associated with operational parameters, such as temperature, and mechanical damage from overpressurization events.

After identifying the chemical and physical properties of crude oils relevant to the specific pipeline failure mechanisms, the committee compared the properties of diluted bitumen with the range of properties in other crude oils commonly transported through pipelines. A finding that diluted bitumen had properties outside this range would require further inquiry into the potential for diluted bitumen to be more likely than other crude oils to cause pipeline releases. A finding that the properties were within the range would not.

Findings

Internal Corrosion and Erosion

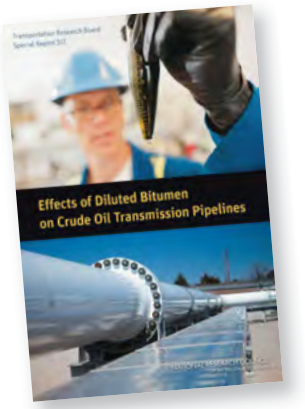
A review of the chemical and physical properties related to the internal corrosion and erosion of pipelines did not indicate that diluted bitumen was

PHOTO: UNIVERSITY OF QUEENSLAND

Bitumen can be extremely viscous and must be combined with lighter oils to move through pipelines. An experiment testing the viscosity of pitch at the University of Queensland, Australia, was begun in 1927; to date, only eight drops have fallen out of the funnel.

PHOTO: TIM EVANSON, FLICKR

The source of oil production in the United States has shifted to shale plays in North Dakota and Texas.



TRB Special Report 311, *Effects of Diluted Bitumen on Crude Oil Transmission Pipelines*, is available from the TRB online bookstore, www.trb.org/bookstore; to view the book online, go to www.trb.org/Publications/Blurbs/169153.aspx.

any more likely than other crude oils to cause these failure mechanisms. Diluted bitumen has densities and viscosities within the range of other crude oils. It flows through pipelines with a velocity and turbulence similar to those of other crude oils and limits the formation of corrosive deposits, as do other crude oils. Shipments of diluted bitumen do not contain unusually high levels of water, sediment, dissolved gases, or other agents that can cause internal corrosion. The organic acids contained in diluted bitumen are not corrosive to steel at pipeline operating temperatures.

Examination of the factors influencing microbial growth revealed that diluted bitumen did not have a higher likelihood than other crude oils of causing microbiologically influenced corrosion. Because its solids content and flow regimes are comparable with those of other crude oils, diluted bitumen does not have a higher propensity to cause the erosion of transmission pipelines.

External Corrosion and Cracking

Pipelines can sustain external damage in the form of corrosion and cracking. Diluted bitumen only contacts the inside of a pipeline and therefore can contribute to external degradation only as a result of changes in a pipeline's operational parameters—specifically, in the pipeline's temperature and pressure levels.

Elevated operating temperatures can increase the likelihood of external corrosion and cracking by causing or contributing to the degradation of protective coatings and by accelerating the rates of certain degradation mechanisms. Elevated operating pressures can cause stress loadings and concentrations that lead to cracking, particularly at sites of corrosion and preexisting damage.

With densities and viscosities comparable with those of other crude oils, diluted bitumen is transported at comparable operating pressures and temperatures. For this reason, the likelihood of temperature- and pressure-related effects is indistinguishable for diluted bitumen and other crude oils of similar density and viscosity. Consequently, diluted bitumen would not create a higher propensity for external corrosion and cracking in transmission pipelines.

Mechanical Damage

Overpressurizing and outside forces can cause mechanical damage to a pipeline and its components. Mechanical forces can cause an immediate release or make a pipeline more susceptible to release by destabilizing the support structures, damaging other components such as valves and joints, and weakening the resistance to other failure mechanisms, such as corrosion.

The study examined several possible ways that the properties of the transported liquid could increase the potential for mechanical damage to the pipe. These included the potential of diluted bitumen to cause pressure surges or to interact with outside forces that can damage pipelines. None of the properties or operating parameters of diluted bitumen shipments, however, differed sufficiently from those of other crude oils to suggest a higher potential for causing or exacerbating mechanical damage in pipelines.

Increased Releases Not Likely

The study committee was asked to "analyze whether transportation of diluted bitumen by transmission pipeline has an increased likelihood of release compared with the pipeline transportation of other crude oils." The committee did not find any causes of pipeline failure unique to the transportation of diluted bitumen. Furthermore, the committee did not find evidence that the physical or chemical properties of diluted bitumen were outside the range of other crude oils, nor did it discover any other aspect of transportation by pipeline that would make diluted bitumen more likely than other crude oils to cause releases.

The results suggest that diluted bitumen will not cause pipeline releases at a rate higher than its share of the crude oil stream. Nevertheless, future pipeline releases will occur and some will involve diluted bitumen. All pipeline releases can be consequential. The committee was not asked to study whether releases of diluted bitumen and other crude oils differ in consequences.

Committee for a Study of Pipeline Transportation of Diluted Bitumen

Mark A. Barteau, NAE, University of Michigan, Ann Arbor, *Chair*
Y. Frank Cheng, University of Calgary, Alberta, Canada
James F. Dante, Southwest Research Institute, San Antonio, Texas
H. Scott Fogler, University of Michigan, Ann Arbor
O. B. Harris, O. B. Harris, LLC, Missouri City, Texas
Brenda J. Little, Naval Research Laboratory, Stennis Space Center, Mississippi
Mohammad Modarres, University of Maryland, College Park
W. Kent Muhlbauer, WKM Consultancy, LLC, Austin, Texas
Srdjan Nesic, Ohio University, Athens
Joe H. Payer, University of Akron, Ohio
Richard A. Rabinow, Rabinow Consortium, LLC, Houston, Texas
George W. Tenley, Jr., Hedgesville, West Virginia

Effective Use of Chip Seals in Minnesota

MELISSA K. COLE AND THOMAS J. WOOD

Cole is Research Project Engineer and Wood is Research Project Supervisor, Office of Materials and Road Research, Physical Research Section, Minnesota Department of Transportation, Maplewood.

For many years, the Minnesota Department of Transportation (DOT) has applied chip seals to preserve asphalt pavements. Long-term data show that the successful application of chip seals has extended the service life of the state's asphalt pavements an average of 6 years.

Problem

In the early 1990s, chip seal use throughout Minnesota declined to an historic low. State and local agencies were not obtaining a consistent quality of performance from the technique. Failures included bleeding—an excess of emulsion—which can cause skidding; loss of aggregate; and a general lack of long-term performance. In addition, loose aggregate was causing vehicle damage.

Research Approach and Solution

Minnesota DOT and the Minnesota Local Road Research Board (LRRB) developed a research-and-implementation project to improve chip seal performance and increase the service life of asphalt pavements.

In the early 1990s, LRRB funded a study by the Minnesota DOT Office of Materials and Road Research on state, national, and international chip seal design methods and best construction practices (*1*). The first phase of the project surveyed all agencies in Minnesota. Results indicated that the lack of a documented, rational design method was a major concern. Chip sealing practice was more an art than an engineered system.

The subsequent literature review evaluated national and international best practices and identified a chip seal design method that with slight modification would be best for Minnesota DOT use (*2*). Developed by Norman McLeod in 1969, the procedure determines the aggregate application rate according to the aggregate gradation, shape, and specific gravity. The binder application rate also depends on the aggregate characteristics, as well as on the traffic volume, the pavement condition, and the binder's residual asphalt content.

The McLeod method prescribes a chip seal that is one stone thick, with a 50 percent to 55 percent initial embedment of the aggregate layer in the asphalt binder. Minnesota DOT's modifications to the method have targeted an initial embedment of 65 percent to 70 percent, to accommodate the state's climate and to minimize damage from snowplows.

Field visits evaluated the performance of various projects. With information from the field visits and from other agencies and the industry, Minnesota DOT researchers recommended a design procedure and construction requirements.

Implementation

The *Minnesota Seal Coat Handbook*, developed in 1998, serves as a practical tool for designers and field technicians. A 2006 revision added guidance on fog

Fog sealing of a chip seal placed on state road.

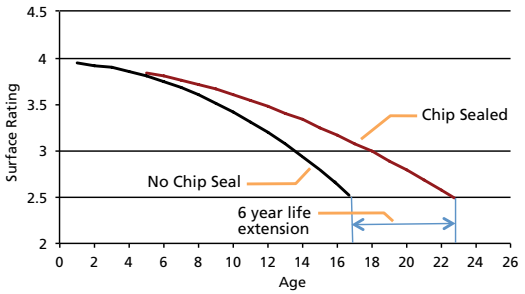


FIGURE 1 New bituminous construction in Minnesota, 1987–2007: surface rating comparison based on network averages (*1*).

sealing and on chip sealing on recreation trails, as well as a section of frequently asked questions (*3*). The primary purpose of the handbook is to provide practical information about seal coat materials, equipment, design, and construction practices for the field inspector.

Education plays a significant role in implementation. Minnesota DOT conducts formal training through the Minnesota Local Technical Assistance Program (LTAP), as well as informal training. The success of local classes has led the National Center for Pavement Preservation and the LTAPs of several states to use Minnesota DOT's chip seal class as part of their training. Minnesota DOT also offers field support to state and local agencies to enhance project delivery and the training of agency and contractor personnel.

Minnesota DOT recommends the placement of chip seals before any deterioration in the pavement is noticeable. The age of the pavements when the first chip seal is placed varies according to the traffic levels, environmental conditions, and the quality of the asphalt.

Before 2007, the average age of a bituminous pavement at placement of the first chip seal was 5 years. More recent experience, however, suggests that the optimal time to apply chip seals may be closer to the construction of the bituminous pavement. An ongoing pooled-fund study is investigating the optimal time to apply treatments such as fog seals and chip seals to optimize pavement life and life-cycle costs (*4*).

Improving Chip Seal Success

New specifications for chip seals from Minnesota DOT include the following:

- No more than 1 percent of aggregates passing the No. 200 sieve;
- Aggregate shape guidelines based on the flakiness index (Federal Lands Highway Procedure T508-96);
- A minimum of 80 percent of the aggregates single-faced crushed;
- Use of polymer-modified emulsions;
- Application of a fog seal after placement of the chip seal;
- The season for installing chip seals ends on August 31; and
- Contracts revised to pay for asphalt binder by the gallon and for aggregate chips by the square yard, so that contractors can benefit from applying the correct quantities.

Benefits

During the mid-1990s, 5 to 7 years was the normal life expectancy of a chip seal in Minnesota. In contrast, recent experience suggests a service life of 12 to 15 years or more before a new chip seal or other maintenance activity must be performed.

Successful chip sealing has increased asphalt pavement life. Data from Minnesota DOT's Pavement Management office show that for all bituminous roads during the span of 1987 to 2007, those that received regular chip seals had a service life averaging 6 years longer than that of pavements that did not receive regular chip seals (Figure 1, above left).

Chip seals offer additional benefits, such as improved safety from increased friction; improved roadway aesthetics with a more uniform pavement surface and small imperfections such as popouts filled in; and protection of the structural integrity of the underlying bituminous pavement.

Minnesota DOT is continuing research into best practices for pavement preservation. For background and updates on chip seals and pavement preservation in Minnesota, visit www.dot.state.mn.us/materials/pavementpreservation.html.

For more information, contact Melissa K. Cole, Research Project Engineer, Minnesota Department of Transportation, 1400 Gervais Avenue, Maplewood, MN 55109; Melissa.cole@state.mn.us.

References

1. Wood, T. J., and R. Olson. Rebirth of Chip Sealing in Minnesota. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1989*, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 260–264.
2. McLeod, N. W., et al. A General Method of Design for Seal Coats and Surface Treatments. In *Proceedings of the Association of Asphalt Paving Technologists*, Vol. 38, 1969, pp. 537–628.
3. Janisch, D. W., F. Gailard, and T. Wood. *Minnesota Seal Coat Handbook, Revised 2006*. Minnesota Department of Transportation, St. Paul, 2006.
4. Optimal Timing of Preventive Maintenance for Addressing Environmental Aging in Hot-Mix Asphalt Pavements. Transportation Pooled-Fund Program, TPF-5(153). www.pooledfund.org/Details/Study/380.

EDITOR'S NOTE: Appreciation is expressed to G. P. Jayaprakash and Frank Lisle (retired), Transportation Research Board, for their efforts in developing this article.

Of related interest: NCHRP Report 680, *Manual for Emulsion-Based Chip Seals for Pavement Preservation*, examines chip seal performance, design, construction, materials selection, and test methods (www.trb.org/main/blurbs/164090.aspx).

Suggestions for Research Pays Off topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2952; gjayaprakash@nas.edu).

CALENDAR

TRB Meetings

April

2–4 Joint Rail Conference*
Colorado Springs, Colorado

9–11 5th International Transportation and Economic Development Conference*
Dallas, Texas

14–16 5th International Conference on Women's Issues in Transportation*
Paris, France

14–17 Transport Research Arena Conference*
Paris, France

16–18 4th International Conference on Roundabouts
Seattle, Washington

22–25 NAFTANEXT: Energizing Sustainable Trade Corridors Across North America—The Intersection of Energy, Environment, Jobs, and Growth*
Chicago, Illinois

22–25 Third International Conference on Transportation Infrastructure*
Pisa, Italy

27–30 Innovations in Travel Demand Forecasting 2014
Baltimore, Maryland

28–30 10th National Conference on Transportation Asset Management
Miami, Florida

May

5–8 American Association of State Highway and Transportation Officials Geographic Information Systems for Transportation Symposium*
Burlington, Vermont

13 Workshop on Natural Gas as a Fuel for Freight Transport
Irvine, California

21–22 Development of Freight Fluidity Performance Measurements
Washington, D.C.

26–28 GeoShanghai International Conference 2014*
Shanghai, China

June

9–12 National Equipment Fleet Management Conference*
Orlando, Florida

24–26 Innovative Technologies for a Resilient Marine Transportation System: 3rd Biennial Research and Development Conference
Washington, D.C.

29–July 2 North American Travel Monitoring Exposition and Conference (NATMEC): Improving Traffic Data Collection, Analysis, and Use
Chicago, Illinois

TBD American Society of Civil Engineers 2nd Transportation and Development Institute Congress*
Orlando, Florida

July

7 Geosynthetics in Roadway Design
Laramie, Wyoming

7–11 7th International Conference on Bridge Maintenance, Safety, and Management*
Shanghai, China

9–11 5th International Conference on Surface Transportation Financing: Innovation, Experimentation, and Exploration
Irvine, California

10–11 9th Strategic Highway Research Program Safety Symposium
Washington, D.C.

13–16 53rd Annual Workshop on Transportation Law
San Francisco, California

15–18 9th International Conference on Short- and Medium-Span Bridges*
Calgary, Alberta, Canada

20–22 GeoHubei International Conference*
Hubei, China

20–23 Symposium on Alternative Intersection and Interchange Design
Salt Lake City, Utah

21–23 14th National Conference on Transportation Planning for Small and Medium–Sized Communities: Tools of the Trade
Burlington, Vermont

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar. To reach the TRB staff contacts, telephone 202-334-2934, fax 202-334-2003, or e-mail TRBMeetings@nas.edu. Meetings listed without a TRB staff contact have direct links from the TRB calendar web page.

*TRB is cosponsor of the meeting.

Dennis P. Hinebaugh

Center for Urban Transportation Research, University of South Florida

Public transportation was an integral part of Dennis Hinebaugh's childhood in 1950s Detroit—while his father took the family's only car to work, Hinebaugh and his mother and brother used overhead electric buses for nearly all their travels. "I didn't appreciate public transportation at the time, I just thought it was the only mode of transportation," he comments. In the 1970s, city bus service was cut back and Hinebaugh departed for college, but his memories of public transportation remained and his desire to work in the public sector grew.

In 1978, Hinebaugh received a bachelor's degree from Michigan State University in urban planning and completed graduate courses in planning at Wayne State University in Detroit, Michigan. In 1980, he joined the Southeastern Michigan Transportation Authority as a planner, working on multimodal systems and a transportation systems management plan. He eventually took a position as a design flows analyst and, later, a project control analyst. In 1985, he moved to Tampa, Florida, to a senior planner position at the Hillsborough Area Regional Transit Authority. Hinebaugh was promoted to Director of Planning, managing the development and implementation of initiatives including the Tampa Downtown Master Circulation Plan, a computerized bus information system for the Marion Street Transitway, a preventive maintenance facility, and a paratransit service plan under the Americans with Disabilities Act of 1991.

"Embrace research, learn from it, challenge it, and—most importantly—put it to good use."

Hinebaugh joined the Center for Urban Transportation Research (CUTR) at the University of South Florida in 1993. As a senior research associate, he conducted projects for Miami–Dade Transit Agency in Miami, Florida, on such topics as large bus cleaning procedures, service planning guidelines, and fare policy strategies. In 1995, Hinebaugh became Transit Program Director, supervising research faculty members and students as well as managing projects on transit operations, planning, short- and long-range plans, fare policy, and more. "Working at CUTR has allowed me to assist transit agencies and the nationwide transit industry in starting to regain the stronghold they once had as an alternative to the automobile," Hinebaugh notes.

Hinebaugh now directs CUTR's National Bus Rapid Transit Institute, a clearinghouse of research and data on bus rapid transit (BRT) funded by the Federal Transit Administration. "Bus rapid transit is a quickly emerging alternative mode of public transportation that offers the performance and benefits of rail with the flexibility and cost-effectiveness of bus service," he explains. In 2012, he chaired an expert review panel for the High-Capacity Transportation Plan in Vancouver, Washington; the plan included BRT lines and the future operations and maintenance of a light rail extension from Portland, Oregon, to Vancouver.

He also serves as administrator of CUTR's National Center for Transit Research (NCTR), a University Transportation Center sponsored by the U.S. Department of Transportation. First established in 1991, NCTR is the only transit-focused university transportation center in the country and has advanced more than 150 research projects, as well as publishing the *Journal of Public Transportation*. Most recently, Hinebaugh was appointed Interim Director of CUTR.

Hinebaugh also is active in the national research community. He has participated in several Transit Cooperative Research Program (TCRP) projects on public transportation and BRT, including project panels on Design and Operation of Bus-Only Shoulder Riding on Heavily Congested Sections of Highways, Implementation Guidelines for Bus Rapid Transit, and Bus Stop Locations on Major Streets and Highways. In 1997, Hinebaugh joined the Public Transportation Marketing and Fare Policy Committee and the Bus Transit Systems Committee, which he has chaired since 2010. He has been a member of the Public Transportation Group since 2010 and now serves as vice chair.

"As I look back over my career, I feel that I have helped make public transportation a workable option for people's everyday lives," Hinebaugh comments. He recalls his early experiences with TRB activities: "During my time at transit agencies, we periodically used the research coming out of TRB, but I was not all that familiar with the pure research side of transit. At a university, I was thrust into paper writing, presentations, and TRB involvement." As he learned more, he began to appreciate the importance of research, sharing findings, making connections, and sharing knowledge with younger members. "Take full advantage of that experience," Hinebaugh counsels new transportation researchers. "Embrace research, learn from it, challenge it, and—most importantly—put it to good use."

"I owe the success in my career to surrounding myself with overly competent people," he adds. "Working closely with students keeps a person grounded; I can share my history and knowledge, but I learn so much from our younger generation."

Wayne Kittelson

Kittelson & Associates, Inc.

A leading expert in the development of techniques for traffic operational and safety analysis for all types of facilities, Wayne Kittelson also has guided many important initiatives supporting the traffic engineering workforce. As senior principal engineer at Kittelson & Associates, Inc., he has been working with colleagues at Eco-Northwest to develop a plan for smart management of an 80-mile section of the US-97 corridor in central Oregon, in conjunction with two counties, four cities, the Bend Metropolitan Planning Organization, and the Oregon Department of Transportation. The project's goal is to advance investment strategies, operational improvements, funding resources, and governance needs for the corridor—significant issues for urban and rural corridors throughout the nation.

"Research engenders an inquiring mind, the willingness to take risks, initiative, humility, and willfulness, all which typically are found in people who have made the greatest contributions to our profession."

"The project will identify outcome-based performance metrics that can be used either in lieu of or in addition to the traditional volume–capacity ratio, and that, collectively, will be sensitive to all modes, safety, health, community livability, and economic vitality," Kittelson comments.

Since 1978, Kittelson has served on the Highway Capacity and Quality of Service Committee at TRB—as secretary from 1989 to 1995 and also as chair of the Subcommittee on Interpretations. He had a significant role in the development of the 1985 *Highway Capacity Manual* (HCM), as well as its 1994 and 1997 updates, HCM 2000, and HCM 2010. Working on National Cooperative Highway Research Program (NCHRP) Project 3-46, Kittelson helped devise a new method for analyzing unsignalized intersections in the HCM. He also chaired the NCHRP Two-Lane Highway Capacity Project Panel and the Capacity and Operational Effects of Midblock Left-Turn Lanes Project Panel and served on the Expert Task Group on Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies for the second Strategic Highway Research Program (SHRP 2). He is a current member of the Research and Technology Coordinating Committee, which provides research advice to the Federal Highway Administration.

"Research engenders an inquiring mind, the willingness to take risks, initiative, humility, and willfulness, all which typically are found in people who have made the greatest contributions to our profession," Kittelson observes, adding that the results of open, collaborative, and peer-reviewed research—from the Synthesis and Cooperative Research Programs, SHRP 2, and the Innovations Deserving Exploratory Analysis program—can be more quickly incorporated into everyday practice.

In 2007, he and other staff members established the Kittelson Charitable Foundation (KCF), a 501(c)(3) nongovernmental organization supporting the education—from kindergarten through college—of international students who would not be able to attend school otherwise. Inspired by Emmie Asaba, a summer intern from Rwanda, KCF provides tuition payments, school supplies, boarding supplies, meals, and a stipend to encourage families to keep their children in school. The foundation also facilitates student visits to the United States, supports students enrolled at U.S. universities, and facilitates an art exchange between American and Rwandan students.

"Supporting and sustaining an environment of care for the world around us is essential to the practice of this great profession," Kittelson observes.

Kittelson & Associates also fosters a comprehensive student internship program in its offices. Each intern receives individualized, focused attention and mentorship. Academic advisers from students' universities also are integrated into the program. "Personal and professional relationships developed with the student are sustained indefinitely after the internship is completed, to provide the student with another long-term resource," Kittelson explains. "The result is an entering workforce that is informed, prepared, and integrated into the profession."

Along with the student internship program, Kittelson & Associates also facilitates a professor partner program, enlisting professors as postgraduate advisers for staff members and allowing the academics to test research and concepts in a real-world environment. "The professors keep us current on the challenges and frontiers of our profession and they critique and add value to our work products," Kittelson notes. Staff members also are encouraged to take part in professional organizations and volunteer activities. He comments that the most notable peers in transportation practice often are also active members of professional societies or committees. "They are the leaders and initiative-taking doers within the committees," he adds.

Along with his TRB service, Kittelson also is active in the Institute of Transportation Engineers (ITE) and is past president of ITE's Oregon Section. He was the 2013 recipient of ITE's Theodore M. Matson Award for outstanding contributions to the field of traffic engineering and, in 2009, received an Individual Achievement Award from the ITE Western District.

The Walter E. Washington Convention Center at 801 Mount Vernon Place, NW, between 7th and 9th Streets, NW, will host the TRB 94th Annual Meeting, January 11–15, 2015—and has already displayed the meeting banner (at right).

TRB Annual Meeting on the Move

MARK R. NORMAN

The author is Director, Technical Activities, TRB.

For the first time in almost 60 years, the TRB Annual Meeting will be moving to a new venue. The TRB 94th Annual Meeting will be held at the Walter E. Washington Convention Center in Washington, D.C., January 11–15, 2015.

Why Now?

With approximately 12,000 attendees, 4,500 presentations in more than 800 sessions and workshops, 350 committee meetings, 200 exhibits, and 1,600 activities during its four and a half days, the Annual Meeting has grown so much that current venues have been stretched to their limits—and, in some cases, beyond them. The TRB mission is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. Information exchange during the Annual Meeting often has been challenging because of the physical separation of the modes and disciplines among the three Connecticut Avenue Collection hotels—the Washington Marriott Wardman Park, the Omni Shoreham, and the Washington Hilton. Unifying the activities will enhance information exchange.

The long-delayed construction of the Marriott Marquis hotel, adjacent to the Convention Center, will be completed in early 2014. The combination of

TRB Annual Meetings

Year	Site
1922	First TRB Annual Meeting at the Engineering Societies Building, 29 West 39th Street, New York, New York (30 registrants)
1923	1701 Massachusetts Avenue, NW, Washington, D.C. (89 registrants)
1924–1940	NAS Building, 2100 C Street, NW, Washington, D.C. (273 registrants in 1924)
1941–1945	Cities outside of Washington, D.C.—Baltimore, Maryland; St. Louis, Missouri; Chicago, Illinois; and Oklahoma City, Oklahoma—to avoid transportation and congestion in the capital during wartime
1946–1955	NAS Building, augmented by auditoriums of District Chapter of the American Red Cross, Department of State, Department of the Interior, and General Services Administration (1,275 registrants in 1955)
1956–1992	All events in Sheraton Park Hotel—later renamed the Washington Marriott Wardman Park Hotel—beginning in 1956; augmented with Omni Shoreham Hotel beginning in late 1960s
1993–2014	Washington Hilton added to Marriott and Omni Shoreham—the so-called Connecticut Avenue Collection hotels (11,900 registrants in 2014)
2015	Moving to Washington Convention Center, 801 Mount Vernon Place, NW, Washington, D.C.

the meeting space in the Convention Center and the Marriott Marquis should meet the needs of the Annual Meeting, with room for future growth. The availability of this major headquarters hotel, however, also has made the Convention Center more attractive to other organizations planning meetings with large attendance, programs, and exhibits. With other organizations vying for the dates when TRB ordinarily conducts its Annual Meeting, TRB staff concluded that if a contract was not set for dates in mid-January, the venue would likely be lost for years to come. After a thorough analysis, the TRB Executive Committee approved the move of the TRB Annual Meeting to the Convention Center, beginning in 2015.

Déjà Vu

This is not the first time that TRB has been faced with the decision on whether or not to change venues to accommodate the meeting's growing attendance and program (see table, page 56). In each case, the decision was made to move the meeting to a facility that initially could house the entire event. As the meeting grew, other nearby facilities were added, until it became again necessary to move to a larger venue to bring everything back under one roof.

The Annual Meeting has been held each year since 1956 in the Washington Marriott Wardman Park hotel (formerly the Sheraton Park). The Omni Shoreham and, later, the Washington Hilton hotels were added to accommodate expanded programming and attendance. Over the past 20 years, TRB has evaluated many options to increase the amount of space for the meeting; however, none of these options had proved to be feasible or desirable.

But now the time has come. Plan now to join colleagues January 11–15, 2015, at the Washington Convention Center to help TRB establish new traditions.

This is the first of a series of articles that will appear in TR News *on the move of the TRB Annual Meeting to its new venue. Upcoming issues will contain articles that provide more details on the Walter E. Washington Convention Center and other information to help attendees prepare for this new experience.*

National Academy of Engineering Elects TRB Volunteers

Six of the 67 new members of the National Academy of Engineering (NAE) of the National Academies have served on TRB committees or on the Marine Board. With more than 2,450 peer-elected members and foreign associates, NAE provides engineering leadership in service to the nation; election to NAE is among the highest professional distinctions accorded to an engineer. The newly elected members include the following:

- **Carlos F. Daganzo**, Chancellor Professor of the Graduate School and retired Robert Horonjeff Chair in Civil and Environmental Engineering, University of California, Berkeley (UC Berkeley), for engineering contributions to traffic, transportation, and logistics systems and operations. Daganzo is a past member of TRB's Transportation and Network Modeling Committee.
- **J. Karl Hedrick**, James Marshall Wells Academic Chair and professor of mechanical engineering, UC Berkeley, for analysis and control methods for nonlinear systems with application to practical problems. Hedrick served on the committee that produced TRB Special Report 265, *An Assessment of the National Highway Traffic Safety Administration's Rating System for Rollover Resistance*. He also has been active on TRB standing committees and National Cooperative Highway Research Program panels.
- **Geraldine Knatz**, Adjunct Professor, Viterbi School of Engineering, University of Southern California, for international leadership in the engineering and development of environmentally clean urban seaports. She retired in January 2014 after eight successful years as executive director of the Port of Los Angeles, one of the largest seaports in the United States. Knatz is the 2009 recipient of the Thomas B. Deen Distinguished Lectureship. She also served as chair of TRB's Marine Board and provided input on TRB policy studies on the marine transportation system and on landside access to U.S. ports.
- **R. Keith Michel**, President, Webb Institute, for contributions to the design, construction, and operation of efficient, environment-friendly ships. A former chair of the Marine Board, Michel also has served on four policy study committees—two of which he chaired.
- **Craig E. Philip**, Chief Executive Officer, Ingram Barge Company, for contributions in information technology and management innovation in the intermodal, rail, and inland waterway industries. Philip is a former member of the TRB Executive Committee and its Subcommittee on Planning and Policy Review. He is a past member of the Marine Board and a current member of the National Cooperative Freight Research Program Oversight Committee.
- **Ian A. Waitz**, Dean of Engineering and Jerome C. Hunsaker Professor of Aeronautics and Astronautics, Massachusetts Institute of Technology, for analysis of environmental effects of aviation that have enabled practical environmental regulations. Waitz was a member of the committee that produced TRB Special Report 307, *Policy Options for Reducing Energy Use and Greenhouse Gas Emissions from U.S. Transportation*.

Photo: U.S. Army Corps of Engineers

U.S. Army Corps of Engineers inspectors assess a bridge. An NCHRP project will develop procedures to determine acceptable bridge foundation movement.

Bridge Superstructure Tolerance to Foundation Movements

Geotechnical engineers use loadings provided by the bridge designer to estimate foundation movements and report findings. The design of the structure then can accommodate the anticipated total and differential movements to satisfy postconstruction bridge performance requirements and to mitigate maintenance issues. The current American Association of State Highway and Transportation Officials' *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*, however, does not provide clear criteria for movement limitations.

Drexel University has received a $350,000, 30-month contract (National Cooperative Highway Research Program Project 12-103, FY 2012) to develop procedures to determine the acceptable levels of bridge foundation movements and to propose revisions to the *LRFD Bridge Design Specifications*.

For more information, contact Waseem Dekelbab, 202-334-1409 or wdekelbab@nas.edu.

Improving Rail Transit Safety at Platform Interfaces

Research is needed to assist transit agencies in improving the safety of platform–train and platform–guideway interfaces. Oregon State University has received a $275,000, 18-month contract [Transit Cooperative Research Program (TCRP) Project A-40, FY 2013] to develop a manual for practitioners to improve safety, focusing on rail transit systems in which car floors are level or near level to the platform.

The manual should present national standards and regulations, identify the magnitude and severity of incidents based on historical data, assess possible correlations between incidents and interface characteristics, categorize and analyze types of incidents, identify factors contributing to hazards, identify and estimate costs of mitigation approaches, and provide a framework for transit agencies and other stakeholders.

For more information, contact Dianne S. Schwager, TRB, 202-334-2969 or dschwager@nas.edu.

Impacts of Statewide Medicaid Transportation Brokerages

Texas A&M Transportation Institute has received a $300,000, 18-month contract (TCRP Project B-44, FY 2013) to present options for Medicaid-funded nonemergency medical transportation services and to evaluate the effects on access to Medicaid services, on human services transportation, and on public transit services, including Americans with Disabilities Act complementary paratransit services.

For more information, contact Dianne S. Schwager, TRB, 202-334-2969 or dschwager@nas.edu.

Improving Occupational Health and Safety Through Bus Operator Workstation Design

Virginia Polytechnic Institute and State University has received a $275,000, 17-month contract (TCRP Project C-22, FY 2013) to update TCRP Report 25, *Bus Operator Workstation Evaluation and Design Guidelines*, and to examine strategies, practices, and policies for reducing bus operator injury and illness attributable to workstation design.

For more information, contact Dianne S. Schwager, TRB, 202-334-2969 or dschwager@nas.edu.

NEWS BRIEFS

PHOTO: NHTSA

Data from the National Highway Traffic Safety Administration show a steady increase in seat belt use among drivers and passengers.

Seat Belt Use Holds Steady in 2013

A survey of seat belt use in the United States shows a slight increase in seat belt use in 2013, according to the National Highway Traffic Safety Administration, which conducted the annual National Occupant Protection Use Survey (NOPUS). Although the 87 percent rate of seat-belt use in 2013 is statistically unchanged from 2012, it maintains a steady increase in use since 1995, when only 60 percent of drivers and passengers buckled up. NOPUS records seat belt use at randomly selected roadway sites throughout the country.

According to the survey, drivers wear seat belts more often than passengers, and in states with primary-enforcement laws—that ticket drivers for not wearing seat belts—91 percent of drivers use seat belts, compared with 80 percent of drivers in states without these laws. The highest proportion of drivers wearing seat belts (93 percent) is found in the western United States. The Northeast has the lowest rate of seat-belt use, at 84 percent, but has experienced the greatest increase in use (four percentage points since 2012) among all the regions.

The weather condition that most often induces drivers to buckle up is light fog—94 percent of drivers wear seat belts in foggy weather, compared with 85 percent in light precipitation and 87 percent in clear weather.

For more information, see www-nrd.nhtsa.dot.gov/Pubs/811875.pdf.

Transit-Oriented Development Leads to Decreased Auto Travel

Transit-oriented land use planning yields lower household vehicle miles traveled (VMT), lower levels of traffic congestion, and increased transit use, according to a Maryland State Highway Administration report. Researchers developed statistical models to analyze the relationship between transit-oriented development (TOD) and travel behavior in the Washington, D.C., and Baltimore, Maryland, metropolitan areas. Data sources included the National Household Travel Survey, U.S. Census and traffic analysis zones, and geocoded transit stations.

Living in a TOD results in a 20 percent reduction in VMT, according to the report. Researchers controlled for several land use factors and included sociodemographics variables in their analysis but did not control for possible self-selection effects. More trips are generated from TOD areas than from non-TOD areas, but fewer of these trips are by car; TODs have greater shares of the transit, bicycle, and pedestrian modes.

In the Washington, D.C., area, the effects of TOD on work and nonwork transportation were more significant than in Baltimore, because of a more efficient transit system and a higher number of work commuters to the region.

For the full report, visit http://www.roads.maryland.gov/OPR_Research/MD-13-SP209B4N-Development-of-a-Framework-for-Transit-Oriented-Development_Report.pdf.

INTERNATIONAL

Statistics Brief Highlights Global Freight Trends

Freight volumes in all modes are rebounding from the economic crisis in 2008, according to data analyzed by the International Transport Forum at the Organisation for Economic Co-operation and Development (OECD). Researchers examined trade figures from 2008 to 2011 in OECD and European Union countries as well as in the United States, China, India, Russia, and Japan.

PHOTO: D. HASENPUSCH, PORT OF HAMBURG MARKETING

Maritime freight volumes across the globe grew by 4 percent in 2011.

Maritime freight grew by 4 percent in 2011 to 8.7 billion tonnes loaded—6 percent above the precrisis peak in 2008—and sea cargo reached 42.8 billion tonne-miles. The data show developing countries outpacing developed countries in terms of maritime freight; nine of the 10 busiest container ports in the world are located in Asia, and seven of those ports are in China.

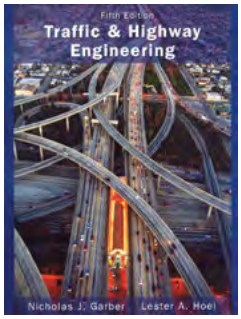
After rebounding 20 percent in 2010 to a total of 172 billion tonne-kilometers, air freight experienced no growth in 2011 and, according to preliminary data, declined by 1.5 percent in 2012. Rail freight in OECD countries and in the United States grew approximately 3 percent in 2011; in Russia and China, rail freight increased by 6 and 7 percent, respectively. At approximately 3.5 trillion tonne-kilometers in 2011, OECD countries together have the highest rail freight volumes of the regions studied.

Although road freight stagnated in OECD countries and in the EU—increasing by only 1 percent in 2011—road freight in China and India grew rapidly from 2008 to 2011. In China, road freight increased 13 percent in 2009, 17 percent in 2010, and 18 percent in 2011, to 5.1 trillion tonne-kilometers. Inland waterway freight surpassed precrisis levels in OECD countries, the United States, and China. China has the highest levels of inland waterway freight among the regions studied, with an increase of more than 40 percent since 2008, to more than 2.5 trillion tonne-kilometers.

For more information on International Transport Forum transportation statistics, visit http://internationaltransportforum.org/statistics/index.html.

BOOK SHELF

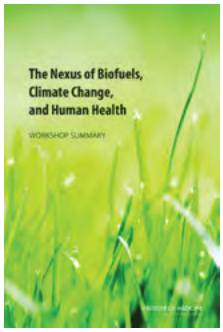
Traffic and Highway Engineering, 5th Edition



Nicholas J. Garber and Lester A. Hoel. Cengage Learning, 2015; 1,284 pp.; $198.95; 978-11-3360-515-7.

The fifth edition of this best-selling text focuses exclusively on traffic and highway engineering—the role of transportation in society, employment opportunities, and historical consequences. Updated material, including 150 new and revised problems, reflects new texts, methods, procedures, and technology. Nicholas Garber is a past member and Lester Hoel a past chair of the TRB Executive Committee.

The Nexus of Biofuels, Climate Change, and Human Health: Workshop Summary



Roundtable on Environmental Health Sciences, Research, and Medicine, Institute of Medicine. National Academies Press, 2013; 200 pp.; $54; 978-03-0929-241-2.

In January 2013, the Institute of Medicine held an interactive public workshop on the intersection of biofuels, climate change, and human health. This summary addresses the impacts of biomass feedstock as an energy resource on air, water, land use, food, and society, and examines the state of the science and health policy implications of using different biofuels as an energy source.

Urban Street Design and Planning

Edited by A. Pratelli. WIT Press, 2013; 152 pp.; $154; 978-18-4564-847-3.

Addressed in this volume are operations, safety, costs and benefits, and control and geometric aspects associated with street design and roadway network planning in urban areas.

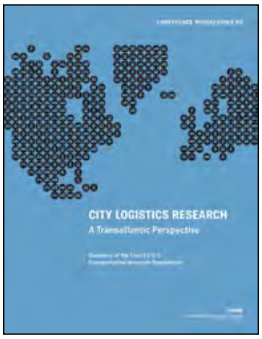
Overcoming Barriers to Electric-Vehicle Deployment: Interim Report

National Research Council. National Academies Press, 2013; 68 pp.; $36; 978-03-0928-448-6.

Appointed by the National Research Council, the Committee on Overcoming Barriers to Electric-Vehicle Deployment documents its findings in this interim report, which focuses on the near term. Addressed in this volume are infrastructure needs for electric vehicles, barriers to deploying the infrastructure, and the role of the federal government in overcoming the barriers. The report focuses on light-duty electric vehicles, specifically plug-in electric vehicles, battery electric vehicles, and plug-in hybrid electric vehicles. A final, comprehensive report will be issued later in 2014.

The titles in this section are not TRB publications. To order, contact the publisher listed.

TRB PUBLICATIONS



City Logistics Research: A Transatlantic Perspective

Conference Proceedings 50

This volume comprises the presentations and discussions at an international symposium, May 2013 in Washington, D.C., the first in a series of four to be conducted by an international consortium of the European Commission, the Research and Innovative Technology Administration, and TRB.

2013; 98 pp.; TRB affiliates, $42.75; nonaffiliates, $57. Subscriber categories: freight transportation; planning and forecasting.

Travel Behavior 2012, Vol. 1

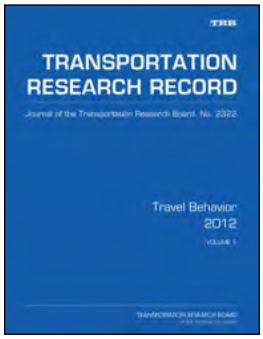
Transportation Research Record 2322

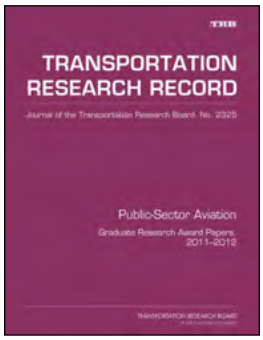
The papers in this volume explore hybrid choice sets in semicompensatory models, integrating walkability into planning practice, network route-choice evolution in a real-world experiment, a dynamic analysis of tourists' choices, and more.

2012; 137 pp.; TRB affiliates, $51.75; nonaffiliates, $69. Subscriber category: planning and forecasting.

The TRR Journal Online website provides electronic access to the full text of more than 13,000 peer-reviewed papers that have been published as part of the Transportation Research Record: Journal of the Transportation Research Board *(TRR Journal) series since 1996. The site includes the latest in search technologies and is updated as new TRR Journal papers become available. To explore the TRR Online service, visit www.TRB.org/TRROnline.*

TRB PUBLICATIONS *(continued)*





Travel Behavior 2012, Vol. 2
Transportation Research Record 2323

Travel patterns of the elderly, parental attitudes toward children walking and bicycling to school, a probit model of individuals' work arrangement choices, the dynamics of automobile ownership under rapid growth, and other subjects are addressed in this volume.

2012; 109 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber category: planning and forecasting.

Intelligent Transportation Systems and Vehicle–Highway Automation 2012
Transportation Research Record 2324

Authors present research on intervehicle safety warning information systems, traffic incident detection, cooperative adaptive cruise control, vehicle platoon control, coordination of automated guided vehicles at intersections, and more.

2012; 132 pp.; TRB affiliates, $51.75; nonaffiliates, $69. Subscriber categories: operations and traffic management; planning and forecasting; vehicles and equipment.

Public-Sector Aviation: Graduate Research Award Papers, 2011–2012
Transportation Research Record 2325

Topics explored in this volume include the effect on fares from the market entry of Southwest Airlines, mammal incidents with civil aircraft, depeaking schedules, security checkpoint wait times, social media and airports, and resource allocation with reduced airspace capacity.

2013; 102 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber category: aviation.

Marine Environment, Safety, and Human Factors 2013
Transportation Research Record 2326

The eight papers in this volume examine carbon dioxide and sulfur oxides emissions from container shipping, damage to offshore pipelines by ships, spatial analysis of maritime accidents, and more.

2013; 58 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber categories: marine transportation; environment; safety and human factors.

School Transportation; Operator Education and Regulation; and Traffic Law Enforcement 2013
Transportation Research Record 2327

Authors present research on mode choices to school, school travel routes and their impacts on safety and mode choices, self-reported driving behaviors, safety of new drivers, automatic license plate recognition, and more.

2013; 60 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber category: safety and human factors.

Research and Education
Transportation Research Record 2328

The seven papers in this volume explore a transatlantic dual master's degree program; summer education programs to expose minority students to careers in transportation and science, technology, engineering, and mathematics; workforce needs for high-speed rail; and more.

2013; 53 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber categories: education and training; administration and management; policy.

Winter Maintenance and Preservation 2013
Transportation Research Record 2329

Highway anti-icer performance, remote sensing of weather and road surface conditions, measurement of salt on winter pavements, rural variable speed limits, and extreme weather risk indicators are among the topics addressed in this volume.

2013; 70 pp.; TRB affiliates, $44.25; nonaffiliates, $59. Subscriber categories: maintenance and preservation; safety and human factors.

Marine Transportation and Terminal Operations 2013
Transportation Research Record 2330

Authors present research on such topics as liner shipping services, forecasting cruise ship arrivals, the selection of dredging projects, the use of data from automatic identification systems, and an assessment of the extended lock outage of the Columbia–Snake River.

2013; 112 pp.; TRB affiliates, $48.75; nonaffiliates, $65. Subscriber categories: marine transportation; terminals and facilities.

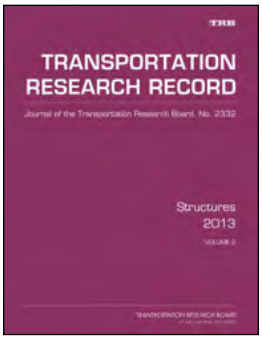
Structures 2013, Volume 1
Transportation Research Record 2331

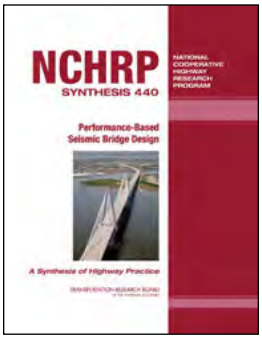
The optimization of design details in orthotropic steel decks, the dynamic behavior of ribbon floating bridges, and the dynamic characterization of a truss bridge are among the topics presented in this volume.

2013; 89 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber category: bridges and other structures.

BOOK SHELF

TRB PUBLICATIONS *(continued)*





Structures 2013, Volume 2
Transportation Research Record 2332

Topics explored in this volume include the seismic retrofit of aerial transit stations, behavior of bell and spigot joints in buried thermoplastic pipelines, flexural behavior of hybrid composite beams, and more.

2013; 73 pp.; TRB affiliates, $44.25; nonaffiliates, $59. Subscriber category: bridges and other structures.

Network Modeling 2013, Volume 1
Transportation Research Record 2333

Addressed in this volume are delays caused by incidents, park-and-ride service on linear travel corridors, variable speed limits, managed lanes, reliable shortest paths in dynamic stochastic networks, and more.

2013; 99 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber categories: planning and forecasting; security and emergencies.

Network Modeling 2013, Volume 2
Transportation Research Record 2334

Research is presented on U.S. Postal Service airmail routing optimization, the impacts of correlations on reliable shortest path finding, online stochastic routing incorporating real-time traffic information, and other topics.

2013; 104 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber categories: planning and forecasting; security and emergencies.

Geomaterials 2013
Transportation Research Record 2335

Blast furnace slag in concrete pavements, an evaluation of aggregate imaging techniques, laboratory compaction techniques for reclaimed asphalt pavement, and a microstructural analysis of granular waste materials are among the subjects explored in this volume.

2013; 129 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: geotechnology; pavements; materials.

Aviation 2013
Transportation Research Record 2336

Examined in this volume are case studies of major airport ground access projects, simultaneous modeling of passenger and cargo demand, models for crew recovery problems, and more.

2013; 116 pp.; TRB affiliates, $48.75; nonaffiliates, $65. Subscriber category: aviation.

Maintenance Services 2013
Transportation Research Record 2337

Authors present research on topics including temporary ramp metering for work zones, injury outcomes and costs for work zone crashes, and the durability of wet night visible pavement markings.

2013; 89 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber categories: maintenance and preservation; pavements.

Urban and Traffic Data Systems 2013, Volume 1
Transportation Research Record 2338

The papers in this volume explore multiday driving patterns and fuel usage, efficient transit analysis, Bluetooth-based travel time estimation, the shortest paths in stochastic time-dependent networks, and other topics.

2013; 90 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber categories: administration and management; operations and traffic management.

Freight Trip Generation and Land Use
NCHRP Report 739–NCFRP Report 19

This report consolidates available freight trip generation models into an electronic database, identifies ways to develop and apply these models, and estimates the models in various case studies.

2012; 149 pp.; TRB affiliates, $50.25; nonaffiliates, $67. Subscriber categories: motor carriers; freight transportation; planning and forecasting.

A Transportation Guide for All-Hazards Emergency Evacuation
NCHRP Report 740

This report focuses on the transportation aspects of evacuation, particularly large-scale, multijurisdictional evacuation, with guidance, strategies, and tools based on an all-hazards approach. A CD-ROM is included with the print edition.

2013; 180 pp.; TRB affiliates, $62.25; nonaffiliates, $83. Subscriber categories: public transportation; security and emergencies.

Evaluation of Methodologies for Visual Impact Assessments
NCHRP Report 741

This report evaluates visual impact assessment procedures, methods, and practices that satisfy or exceed the National Environmental Policy Act and other requirements.

2013; 149 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: highways; environment; planning and forecasting.

TRB PUBLICATIONS *(continued)*

Communicating the Value of Preservation: A Playbook
NCHRP Report 742

This report presents guidance for communicating the value of highway system maintenance and preservation.

2013; 187 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: education and training; highways; maintenance and preservation.

Predicting the Initial Retroreflectivity of Pavement Markings from Glass Bead Quality
NCHRP Report 743

Described in this volume is a laboratory test method to predict the initial retroreflectivity of pavement markings in the field, based on the quality of the applied glass beads.

2013; 74 pp.; TRB affiliates, $39; nonaffiliates, $52. Subscriber categories: highways; materials.

Fuel Usage Factors in Highway and Bridge Construction
NCHRP Report 744

Addressed are fuel usage factors for work items in the construction and maintenance of highways and bridges. This volume includes the Price Adjustment Calculator Tool in Microsoft Excel spreadsheet format.

2013; 136 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: construction; highways.

Left-Turn Accommodations at Unsignalized Intersections
NCHRP Report 745

This report presents guidance on the selection and design of left-turn accommodations at unsignalized intersections, illustrated with 11 case studies.

2013; 51 pp.; TRB affiliates, $34.50; nonaffiliates, $46. Subscriber categories: highways; design; safety and human factors.

Performance-Based Seismic Bridge Design
NCHRP Synthesis 440

Summarized in this volume is the current state of knowledge and practice for performance-based seismic bridge design, which links decision making for facility design with seismic input, facility response, and potential facility damage.

2013; 126 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: bridges and other structures; highways.

High-Performance Concrete Specifications and Practices for Bridges
NCHRP Synthesis 441

This synthesis documents the types of specifications and practices used by state transportation agencies to produce high-performance concrete for bridges and identifies those that have been successful.

2013; 73 pp.; TRB affiliates, $39; nonaffiliates, $52. Subscriber categories: bridges and other structures; highways; materials.

Practices and Performance Measures for Local Public Agency Federally Funded Highway Projects
NCHRP Synthesis 442

This synthesis examines the performance measures, delivery practices, strategies, and tools that are used in the development and delivery of federally funded, local public agency highway projects.

2013; 121 pp.; TRB affiliates, $45.75; nonaffiliates, $61. Subscriber categories: administration and management; highways.

Environmental Optimization of Aircraft Departures: Fuel Burn, Emissions, and Noise
ACRP Report 86

Presented in this volume is a protocol for evaluating and optimizing aircraft departure procedures to reduce noise exposure, emissions, and fuel burn. Included with the print edition is the spreadsheet-based Departure Optimization Investigation Tool on CD-ROM.

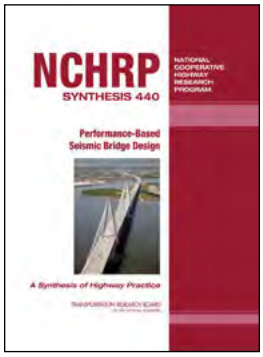
2013; 96 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: aviation; economics; environment.

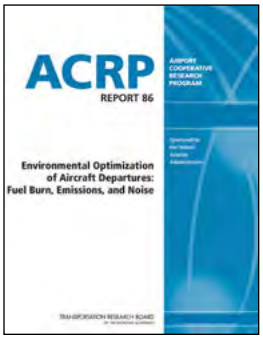
Procuring and Managing Professional Services for Airports
ACRP Report 87

This report provides guidance for airport owners and operators in procuring and managing professional services at airports for planning, environmental, architectural and engineering, information technology, financial, and legal assignments, and more.

2013; 110 pp.; TRB affiliates, $45; nonaffiliates, $60. Subscriber categories: aviation; materials.

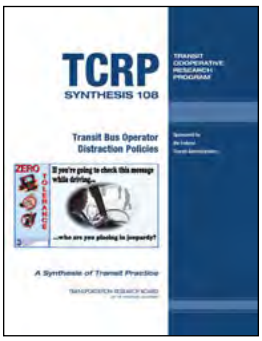
To order TRB titles described in Bookshelf, visit the TRB online Bookstore, at www.TRB. org/bookstore/, or contact the Business Office at 202-334-3213.





BOOK SHELF

TRB PUBLICATIONS *(continued)*



Guidebook to Creating a Collaborative Environment Between Airport Operations and Maintenance
ACRP Report 92

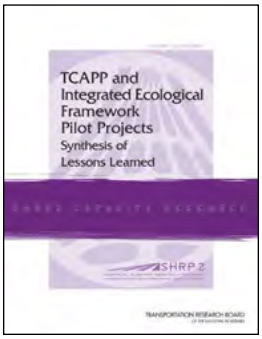
Included in this volume are tools and strategies to increase and improve collaboration between operations and maintenance staffs at airports.

2013; 139 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber category: aviation.

Building a Sustainable Workforce in the Public Transportation Industry: A Systems Approach
TCRP Report 162

Contemporary issues in workforce development, retention, and attraction and public transportation image management are addressed in this volume, which also provides practical tools for resolving a variety of workforce issues.

2013; 203 pp.; TRB affiliates, $56.25; nonaffiliates, $75. Subscriber category: public transportation.



Transit Capacity and Quality of Service Manual, Third Edition
TCRP Report 165

This report presents guidance on transit capacity and quality of service issues and describes the factors influencing these issues. A CD-ROM with PDFs, links to referenced TCRP reports, spreadsheets, and more is included with the print version.

2013; 685 pp.; TRB affiliates, $87; nonaffiliates, $116. Subscriber category: public transportation.

Transit Bus Operator Distraction Policies
TCRP Synthesis 108

This synthesis aims to help transit agencies develop policies and programs to address and prevent distracted-driving incidents.

2013; 92 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber categories: design; education and training; public transportation; safety and human factors.

Freight Data Sharing Guidebook
NCFRP Report 25

Identified in this report are guidelines for sharing freight data, along with barriers and motivators to successful data sharing, with examples from successful case studies.

2013; 61 pp.; TRB affiliates, $36.75; nonaffiliates, $49. Subscriber categories: data and information technology; freight transportation; planning and forecasting.

TCAPP and Integrated Ecological Framework Pilot Projects: Synthesis of Lessons Learned
SHRP 2 Report S2-C41-RW-1

Transportation for Communities—Advancing Projects Through Partnerships (TCAPP) provides guidance on reaching collaborative decisions. Detailed in this report are pilot tests of TCAPP and the Integrated Ecological Framework.

2013; 23 pp. Subscriber categories: environment; highways; planning and forecasting. Available at http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-C41-RW-1.pdf.

Freight Demand Modeling and Data Improvement Strategic Plan
SHRP 2 Report S2-C20-RW-2

This volume outlines seven strategic objectives for innovation in freight travel demand forecasting and data and offers guidance on near- and long-term implementation.

2013; 41 pp. Subscriber categories: data and information technology; freight transportation; highways; planning and forecasting. Available at http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2_C20-RW-2.pdf.

Practitioner's Guide to Incorporating Greenhouse Gas Emissions into the Collaborative Decision-Making Process
SHRP 2 Report S2-C09-RW-2

Presented in this volume is information on how greenhouse gas emissions can be incorporated into transportation planning when different types of collaborative decision-making approaches are used.

2013; 209 pp. Subscriber categories: energy; environment; highways; planning and forecasting. Available at http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-C09-RW-2.pdf.

An Ecological Approach to Integrating Conservation and Highway Planning, Volume 2
SHRP 2 Report S2-C06-RW-2

This report assists transportation and environmental professionals in applying ecological principles—landscape, water resources, and habitat impacts, as well as localized effects—early in the planning process of highway capacity improvements.

2012; 151 pp. Subscriber categories: environment; highways; planning and forecasting. Available at http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-C06-RW-2.pdf.

INFORMATION FOR CONTRIBUTORS TO

TR NEWS

TR News welcomes the submission of manuscripts for possible publication in the categories listed below. All manuscripts submitted are subject to review by the Editorial Board and other reviewers to determine suitability for *TR News*; authors will be advised of acceptance of articles with or without revision. All manuscripts accepted for publication are subject to editing for conciseness and appropriate language and style. Authors receive a copy of the edited manuscript for review. Original artwork is returned only on request.

FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, marine, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, security, logistics, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 words (12 double-spaced, typed pages). Authors also should provide charts or tables and high-quality photographic images with corresponding captions (see Submission Requirements). Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may improve a reader's understanding of the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographs or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information appears. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

LETTERS provide readers with the opportunity to comment on the information and views expressed in published articles, TRB activities, or transportation matters in general. All letters must be signed and contain constructive comments. Letters may be edited for style and space considerations.

SUBMISSION REQUIREMENTS: Manuscripts submitted for possible publication in *TR News* and any correspondence on editorial matters should be sent to the Director, Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, telephone 202-334-2972, or e-mail jawan@nas.edu.

- All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word, on a CD or as an e-mail attachment.
- Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi. A caption should be supplied for each graphic element.
- Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

NOTE: Authors are responsible for the authenticity of their articles and for obtaining written permissions from publishers or persons who own the copyright to any previously published or copyrighted material used in the articles.

HIGHWAY CAPACITY MANUAL 2010

All 4 Volumes Now Available Online!

Choose from Two Comprehensive Formats!

The fifth edition of the essential *Highway Capacity Manual* (HCM 2010) revises the 2000 edition and significantly enhances the way that engineers and planners assess the traffic and environmental effects of highway projects by

- Providing an integrated, multimodal approach to the analysis and evaluation of urban streets from the points of view of automobile drivers, transit passengers, bicyclists, and pedestrians;
- Addressing the application of microsimulation analysis and the evaluation of the results;
- Examining active traffic management in relation to demand and capacity; and
- Exploring specific tools and generalized service volume tables, to assist planners in sizing future facilities.

The multivolume resource is available in print and online:

- The print version contains Volumes 1, 2, and 3 in a boxed set and includes a registration code for the online-only Volume 4.
- The full online version includes all 35 chapters in Volumes 1 through 4.

Volume 1 presents Concepts; Volume 2, Uninterrupted Flow; and Volume 3, Interrupted Flow. Volume 4 consists of supplemental chapters on methodological details and emerging issues; interpretations, clarifications, and corrections; comprehensive case studies; and a technical reference library.

ORDER TODAY:

- **Print version plus online Volume 4: http://books.trbbookstore.org/hcm10.aspx**
- **Volumes 1 through 4 online: http://trb.metapress.com**

Multiuser licenses are available for Volume 4 and for the full electronic format—contact TRBSales@nas.edu for details.

TRN290